

Initial Environmental Examination

Draft
November 2019

INO: Geothermal Power Development Project - Dieng Unit 2 Project Component

Prepared by P. T. Geo Dipa Energi for the Asian Development Bank

CURRENCY EQUIVALENTS

(as of 1 October 2019)

Currency unit	–	Rupiah (IR)
IR1.00	=	\$0.00071
\$1.00	=	IR14,168.32

ABBREVIATIONS

ADB	–	Asian Development Bank
AMDAL	–	<i>Analisis Mengenai Dampak Lingkungan</i>
CTF	–	Clean Technology Fund
CITES	–	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CAP	–	corrective action plan
DMF	–	design and monitoring framework
DO	–	dissolved oxygen
EMP	–	environmental management plan
EMoP	–	environmental monitoring plan
EPC	–	engineering, procurement, and construction
FEED	–	front-end engineering design
FGD	–	focus group discussion
GDE	–	PT Geo Dipa Energi
GRC	–	grievance redress committee
GRM	–	grievance redress mechanism
HSE	–	health, safety, and environment
IEE	–	initial environmental examination
ORC	–	organic Rankine cycle
PMC	–	project management consultant
PMU	–	project management unit
RUPTL	–	<i>Rencana Umum Penyediaan Tenaga Listrik</i> (Electricity Power Supply Business Plan)
SAGS	–	steam above ground gathering system
SCS	–	stakeholder communication strategy
SPS	–	Safeguard Policy Statement
TOR	–	terms of reference

WEIGHTS AND MEASURES

°C	–	degree celsius
dB(A)	–	A-weighted decibel
ha	–	hectare
km	–	kilometer
kV	–	kilovolt
MW	–	megawatt
MWh	–	megawatt-hour
mg/L	–	milligram per liter
µg/m ³	–	microgram per cubic meter
mg/Nm ³	–	milligram per normal cubic meter
m ²	–	square meter
ppm	–	parts per million

NOTE

In this report, "\$" refers to United States dollars.

This initial environmental examination is a document of the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature. Your attention is directed to the "terms of use" section of this website.

In preparing any country program or strategy, financing any project, or by making any designation of or reference to a particular territory or geographic area in this document, the Asian Development Bank does not intend to make any judgments as to the legal or other status of any territory or area.

TABLE OF CONTENTS

1	INTRODUCTION.....	13
1.1	Overview of the Project	15
1.2	Project Implementation Arrangements.....	16
1.3	The Need for Environmental Assessment.....	17
1.3.1	National Requirements.....	17
1.3.2	Environmental requirements of ADB.....	17
1.4	IEE Methodology	18
2	Policy, Legal, and Administrative Framework	19
2.1	National environmental requirements	19
2.1.1	Environmental Agency	19
2.1.2	Environmental regulations.....	19
2.1.3	Other applicable regulations	21
2.1.4	Applicable Environmental Standards	23
2.1.5	Relevant International Environmental Agreements.....	28
2.2	Environmental requirements of ADB	29
2.2.1	Environmental requirements	30
2.2.2	Disclosure requirements	30
3	Description of the Project	34
3.1	Brief History of Dieng Geothermal Field.....	34
3.2	Development and Need for the Project.....	34
3.3	Location	34
3.4	Project Components	35
3.4.1	Well Development	37
3.4.2	Steam Above Ground System.....	38
3.4.3	Power Generation System	41
3.5	Project Activities	42
3.5.1	Pre-construction Phase.....	42
3.5.2	Construction Phase	43
3.5.3	Operation Phase	44
3.5.4	Decommissioning Phase.....	44
3.6	Overall Project Implementation Arrangements and Schedule	44
3.6.1	Overall Project Implementation Plan.....	45
4	Description of the Environment (Baseline Data)	46
4.1	Project Area of Influence	46
4.2	Physical Environment.....	48
4.2.1	Climate and Meteorology	48
4.2.2	Ambient Air Quality and Noise	50
4.2.3	Geology and Topography.....	55
4.2.4	Hydrology and Water Resources	57
4.3	Biological Environment	67
4.4	Socio-economics and Land Use.....	79
4.5	Community Health	86

4.6	Occupational Health and Safety	87
4.7	Corporate Social Responsibility.....	91
5	ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES	93
5.1	Scoping of Environmental Risks and Impacts	93
5.2	Project Phases	95
5.2.1	Front end engineering design (FEED)/Detailed engineering design	95
5.2.2	Demolition of Existing Structures at the Project Site.....	96
5.2.3	Construction Phase	97
5.2.4	Operation Phase	98
5.2.5	Decommissioning Phase.....	98
5.3	Assessment of Major Impacts	98
5.3.1	Impact on ambient air quality	98
5.3.2	Noise	105
5.3.3	Water use and impact on local water resource	110
5.3.4	Impact on surface and groundwater quality	117
5.3.5	Generation of Waste	118
5.3.6	Impacts on Land, Agriculture, Risk of Natural Disasters.....	120
5.3.7	Impact on fauna, flora, biodiversity	121
5.3.8	Community and Occupational Safety Risks	122
5.3.9	Greenhouse Gas (GHG) Emissions.....	124
5.3.10	Decommissioning	125
5.3.11	Cumulative Impacts.....	126
5.4	Safety Risk Assessment for existing and proposed facilities.....	127
5.4.1	Methodology	127
5.4.2	HAZID Findings	130
5.4.3	Risk of explosion resulting from rupture in organic fluid storage tank	141
6	ANALYSIS OF ALTERNATIVES	144
6.1	“No project” option	144
6.2	“With project” options	146
6.2.1	Site suitability	146
6.2.2	Renewable energy utilization	147
6.2.3	Options for cooling system	147
6.2.4	Options for the alignment of power transmission line	149
7	INFORMATION DISCLOSURE, CONSULTATION, PARTICIPATION	153
7.1	Introduction	153
7.1.1	National requirements for public participations	153
7.1.2	Consultation based on SPS 2009	154
7.2	Consultation Methodology.....	154
7.3	Results of Public Consultations during the preparation of the IEE.....	156
7.3.1	The Consultations in March 2019	156
7.3.2	The Consultations in September 2019.....	158
7.3.3	Targeted stakeholder consultations	160
7.4	Consultations and information during implementation.....	161
8	GRIEVANCE REDRESS MECHANISM	163
8.1	Current GDE Process of Handling Complaints.....	163
8.2	Handling Environmental Complaints at MOEF	164

8.3	Project GRM.....	164
9	ENVIRONMENTAL MANAGEMENT PLAN.....	170
9.1	Introduction	170
9.2	Institutional arrangements and responsibilities for EMP implementation	170
9.3	Contractor Obligations Prior to Construction.....	174
9.4	Impacts and Mitigation Measures.....	176
9.4.1	Reporting.....	190
9.4.2	Training, Capacity Building Plan	190
9.4.3	Emergency Preparedness and Response Requirements During Construction.....	191
9.4.4	EMP Implementation Cost Estimates.....	191
10	CONCLUSION AND RECOMMENDATION.....	195

List of Appendixes

Appendix 1	List of Participants during Consultations
Appendix 2	Chance Find Procedures for Physical Cultural Resources
Appendix 3b	Air Quality Dispersion Modeling
Appendix 4b	Noise Assessment Study
Appendix 5b	Biodiversity Action Plan
Appendix 6	Emergency Response Preparedness and Response System Review Report
Appendix 7	Quantitative Risk Assessment
Appendix 8	Format of Environmental Monitoring Report

LIST OF TABLES

Table 1.1: Project Details	15
Table 1.2: Financing Plan	16
Table 2.1: Other Applicable National Regulations	21
Table 2.2: Noise Standards.....	24
Table 2.3: Standards for Unpleasant Odour	25
Table 2.4: Air Quality Standards	25
Table 2.5: Effluent Standards.....	27
Table 2.6: Water Quality Management and Pollution Control Standards	27
Table 2.7: Indonesia Relevant International Environmental Agreements.....	28
Table 2.8: Environmental Classification based on SPS 2009.....	29
Table 2.9: Implications of SPS 2009 to the Project	31
Table 3.1: Key Project Components of Dieng Unit 2	36
Table 3.1: Production Well Plan for Dieng Unit 2	37
Table 3.3: Injection Well Plan for Dieng Unit 2	38
Table 3.3: Power Plant Overview of Dieng Unit 2.....	41
Table 4.1: Average Monthly Temperature and Humidity in 2018	49
Table 4.2: Number of Rainy Days in 2018	49
Table 4.3: Wind Speed Recorded in 201	50
Table 4.1: Ambient Air Quality Monitoring Results of 1 st Semester/2018	53
Table 4.1: Ambient Air Quality Monitoring Results of 2 nd Semester/2018	53
Table 4.1: Additional Air Quality Sampling Results (April 2019).....	54
Table 4.1: Water Quality Monitoring Results of Tulis, Putih, and Sidolog Rivers	61
Table 4.8: Stream Water Quality (Well pad #29)	63
Table 4.9: Groundwater Quality of Community Wells	63
Table 4.10: Rainwater Quality	64
Table 4.1: Analytical Results and Fertility Status of the Soil Samples	64
Table 4.12: Soil Analytical Results - Karang Tengah, Sikunang, and Pranten.....	66
Table 4.1: Historical Eruptions of Dieng Plateau	66
Table 4.14: Occurrence and Relative Frequency of Tree Species	70
Table 4.15: Mammals and Amphibian Species.....	71
Table 4.1: Bird Species Identified	72
Table 4.17: Migratory birds of prey (Baskoro, 2019)	74
Table 4.1: Phytoplankton Occurrence and Distribution	75
Table 4.19: Benthos Occurrence and Distribution	75
Table 4.20: Fish Identified	76
Table 4.21: Critical Habitat Criteria and Justification Applicable for Dieng.....	77
Table 4.22: Village Population and Density at Village Level.....	80
Table 4.23: Demographic Profile at District Level.....	80
Table 4.24: Employment of the Respondents.....	81
Table 4.25: Medical Cases Treated at District Level (2018).....	86
Table 4.26: Standard Operating Procedures of GDE Dieng.....	90
Table 4.27: Corporate Social Responsibility (CSR) Activities in 2018.....	91
Table 5.1: Screening and scoping of environmental impacts	94
Table 5.2: Worker Exposure Limits to H ₂ S	100
Table 5.2: Short-term Symptoms and Effects of H ₂ S.....	100
Table 5.4: Source Parameters for Cooling Towers.....	102
Table 5.5: Predicted H ₂ S Concentration in Sensitive Receptors	104
Table 5.6: Noise-sensitive receptors in Dieng	106
Table 5.7: Calculated A-weighted downwind sound pressure level LA(DW) at the NSRs (contribution level) at 1,5 m above ground for operating scenarios D-O0, D-O1, D-O5, D-C1 and D-C2.....	107
Table 5.8: Overall compliance overview	108
Table 5.9: Anticipated water demand during facility construction and operation.....	111
Table 5.10: Surface water bodies in the project area of influence	113
Table 5.10: Freshwater saving measures considered in project design.....	116

Table 5.10: Drilling and Cementing Materials	119
Table 5.13: Ranking of risks based on consequence of impact	128
Table 5.14: Ranking of risks based on likelihood of impact.....	129
Table 5.15: Identified risks without (left) and with (right) mitigation measures, Operation Phase	131
Table 5.10: Recommended additional measures, cost estimates as per Monte Carlo simulation	140
Table 5.17: Assumptions used for the ALOHA simulation.....	142
Table 4.1: “With project” and “no project” options.....	145
Table 6.2: Analysis of different cooling systems	147
Table 4.1: Summary of the environmental and social impacts of the transmission line	149
Table 6.4: Cost Estimates of the Transmission Line Options	149
Table 7.1: Key Laws and Regulations Mandating Public Participation.....	153
Table 7.2: Profile of Participants during Consultations, March 2019	156
Table 7.3: Summary of Public Consultations in March 2019	156
Table 7.4: Profile of Participants during Consultations, September 2019	159
Table 7.5: Summary of Public Consultations in September 2019	159
Table 7.6: Summary of Targeted Stakeholder Consultations	161
Table 8.1: Current Grievance Redress Procedure in Place at GDE Patuha	163
Table 8.2: Grievance Redress Procedure complaints according to <i>Permen LH 9/2010</i>	164
Table 8.3: Sample Grievance Redress Form.....	166
Table 9.1: Roles and Responsibilities During Implementation	173
Table 9.2: Environmental Management Plan for Dieng Unit 2.....	177
Table 9.1: Environmental Monitoring Plan for Dieng Unit 2.....	185
Table 9.4: Proposed Environmental Site Inspection and Monitoring Checklist (to be adjusted by PMC) .	193

LIST OF FIGURES

Figure 1.1: Geothermal Energy Potential.....	13
Figure 1.2: Location of the Project	14
Figure 1.3: Project Management Arrangements	17
Figure 2.1: Simplified Flowchart of Environmental Permitting Process	23
Figure 3.1: Project Location	35
Figure 4.1: General Layout of Dieng Unit 2 and Surface Facilities.....	37
Figure 3.3: Location of the Wells for Dieng Unit 2	38
Figure 3.4: Process Flow Diagram of SAGS for Unit 2.....	39
Figure 3.4: Process Flow Diagram of Power Generation System for Unit 2.....	42
Figure 4.1: Project Area of Influence	46
Figure 4.1: Rainfall Rate in Dieng Plateau 2008 - 2012	48
Figure 4.3: Regular Air Quality Monitoring Stations.....	51
Figure 4.1: Air Quality Monitoring Stations	52
Figure 4.1: Ambient Noise Levels Measured in 2018.....	54
Figure 4.6: Cross-section of Subduction Zone beneath Java, Bali, Lombok, and Sumbawa.....	55
Figure 4.1: Regional Tectonic Features of Indonesia	56
Figure 4.1: Dieng Geological Features	57
Figure 4.1: Surface Water Bodies in Dieng Plateau	58
Figure 4.10: Indonesia Seismic Hazard Map	67
Figure 4.11: Typical Ecosystem and Habitat	68
Figure 4.12: Biodiversity Survey Areas.....	69
Figure 4.1: Oriental Honey-buzzards Observed	74
Figure 4.14: Area of Analysis of Dieng Project Area	79
Figure 4.15: Income Level of the Respondents	82
Figure 4.16: Education Profile of the Respondents	83
Figure 4.17: Geothermal Potential Area Overlaid with Land Use	84
Figure 4.18: Existing Land Uses and Land Cover within Dieng Plateau	85
Figure 4.19: Candi Dieng Compound	85
Figure 4.20: ISO 14001:2015 Certificate of GDE Dieng	88
Figure 4.21: Occupational Health & Safety Management System Certificate of GDE Dieng	89
Figure 5.1: A-weighted sound pressure levels (LA(Lt) at 1.5m above ground for scenario D-O2 (Unit 1, Unit 2 and Unit 3 – contribution)	108
Figure 5.1: Surface water bodies in and around Dieng Plateau.	112
Figure 5.3: Existing freshwater storage pond at Pad 24.....	113
Figure 5.3: Water supply arrangements during drilling operations	115
Figure 5.5: Design of well casing	118
Figure 5.5: Geothermal System Processes Affecting CO ₂ Emissions.....	125
Figure 5.7: Risk Matrix	130
Figure 5.7: ALOHA simulation for rupture of organic fluid storage tank	144
Figure 4.21: Schematic diagram of a cooling system	148
Figure 4.21: Location of Option 1.....	150
Figure 6.3: Location of Option 2-1	150
Figure 6.4: Location of Option 2-2	151
Figure 6.5: Location of Option 3.....	151
Figure 7.1: Public Consultation in Dieng, March 2019.....	155
Figure 7.2: Public Consultation in Dieng, September 2019.....	155
Figure 8.1: Basic grievance redress mechanism	165
Figure 8.2: Project GRM	169
Figure 8.2: HSE and Safeguards Coordination Arrangements in the PMU.....	172

Executive Summary

Introduction

1. P. T. Geodipa Energi (GDE) is a state-owned-enterprise since December 2011 and has requested the Asian Development Bank (ADB) to provide financing of additional geothermal generation capacity of 110 MW for Dieng Unit 2 (55 MW) in Wonosobo, Central Java and Patuha Unit 2 (55 MW) in Ciwidey, West Java. GDE owns and manages the existing Unit 1 (55MW) in Dieng and Unit 1 (55MW) in Patuha.

2. The project will support the target of the Government of Indonesia (GOI) to increase the contribution of renewable energy sources to 23% by 2025 where geothermal represents 7% requiring an additional 5.8 GW from the present capacity of 1.8 GW. The additional capacity will be consistent in meeting the commitment of GOI to the Nationally Determined Contribution of reducing greenhouse gas emissions to 29% by 2030.

3. The Dieng-Patuha expansion project is included in the Fast Track Program which is a flagship program of GOI for electricity infrastructure development. The expansion is also identified in the National Strategic Program for Electricity Supply Business Plan (*Rencana Umum Penyediaan Tenaga Listrik* or RUPTL) 2019-2028 as needed in order to achieve the target geothermal capacity by 2025. These additional power generation projects are presented in the National General Energy Plan (*Rencana Umum Energi Nasional* or RUEN) of the Ministry of Energy and Mineral Resources (Kementerian Energi dan Sumberdaya Mineral). All these efforts are driven by the Government Regulation No. 79 of 2014 on the National Energy Policy ("2014 NEP).

Project Description

4. The Dieng Unit 2 facilities will require the following main components:

- (i) A total of six production wells (of which one well is existing);
- (ii) A total of five new injection wells;
- (iii) Power plant with an installed capacity of 1 x 55 MW using a combined cycle power plant technology (i.e., back pressure turbine and organic Rankine cycle bottoming for steam and brine);
- (iv) Steam above ground gathering system (SAGS) consisting of about 9.13 kilometer (km) steam pipelines to connect Unit 2 geothermal power plant to the production wells;
- (v) About 5.05 km of injection pipelines to connect Unit 2 to the injection system;
- (vi) An underground electric transmission line of about 6.9 km to connect Unit 2 to the existing substation in Unit 1; and
- (vii) Access road of about 1.8 km.

5. The combined cycle power plant can produce more power for the same amount of geothermal fluid production than single flash power plant. A pH modification on the combined cycle power plant will be employed as an effective solution to reduce silica scaling rates and ensure the increase in the pressure of steam separation. Silica scaling is one of the technical challenges in geothermal power production in Indonesia. Silica can restrict the flow of fluid reducing heat transfer efficiency and is expensive to remove from the equipment.

Implementation Arrangements

6. GDE will be the executing agency responsible for the overall supervision and management of project implementation. A project management unit (PMU) will be established by the GDE to undertake the overall day-to-day management and supervision of project activities in coordination with the project management consultant (PMC). The PMC will be engaged to provide technical support to the PMU in carrying out their project management functions. The PMU will have an environmental safeguard staff both in the Head Office in Jakarta and in the site office at Dieng Unit 2 to ensure compliance to the requirements of the GOI and ADB. The PMC will similarly engage international and national environmental experts to undertake monitoring and reporting to GDE and its contractors' performance against the environment safeguards covenants included in the ADB Loan Documents. They will be responsible for making recommendations for corrections or improvement where non-compliance are identified. The project is expected to be implemented from 2020-2024.

Environmental Requirements

7. On 3 October 2009, the Ministry of Environment and Forest issued Law No. 32 of 2009 on Environmental Protection and Management which requires that every business or activity that causes substantial impact on the environment shall be subject to the environmental impact assessment (EIA) process (*Analisis Mengenai Dampak Lingkungan* in Indonesia or AMDAL). Article 23 describes the activities, and for any business or activity where AMDAL is required, an environmental management plan (RKL) and environmental monitoring plan (RPL) will be required together with the environmental impact assessment study (ANDAL).

8. Dieng Unit 2 is subject to AMDAL and an environmental permit has been issued based on ANDAL Addendum 2004 which covered the development of Unit 1, Unit 2, Unit 3 and Unit 4. Law No. 32 provides that if there are no changes in the project scope, the approval is still valid. In the case of Dieng Unit 2, ANDAL Addendum will be required to secure an environmental permit to address the changes on the transmission line from Unit 2 to the existing Dieng substation near Unit 1, a new combined cycle power plant technology, and a pipeline from Wellpad #9 to the power plant in Unit 2. The terms of reference for the ANDAL Addendum have been completed and GDE is engaging an MOEF-accredited 3rd party provider to do the work.

9. The Safeguard Policy Statement (SPS) 2009 embodies the environmental requirements and review procedures of ADB for all the projects and grants they finance. Under SPS 2009, projects or grants are screened and categorized based on their potential environmental impacts. Following the classification of SPS 2009, Dieng Unit 2 is category B for environment requiring the preparation of an initial environmental examination (IEE). A category B project is considered likely to have adverse environmental impacts that are less adverse than category A project. These impacts are site-specific, few if any of them irreversible, and in most cases mitigation measures can be more readily designed.

Description of the Existing Environment

10. The Project is located in a largely agricultural area comprising Modified Habitat, within a broader landscape which has an extensive tract of forested Natural Habitat (the Dieng Mountains) with streams and rivers that drain into Tulis and Serayu watersheds. The area in Dieng Mountains has an elevation of up to 2,060 m above mean sea level (masl) with distinct subtropical highland climate characterized by rainy season occurring from October to May and a brief dry season from

June to September. Total rainfall rate in Dieng Plateau is about 2,700 mm per year. In 2018, the number of rainy days range from one day in August to 31 days in December. Average annual temperature in Dieng is 14°C and humidity ranging from 73% to 88%. Ground frosts have been recorded occasionally every year particularly in late evenings and mornings of July and August. This situation may last for an average of one week, and it is called as '*Bun Upas*' by local people.

11. As required by MOEF, a 3rd party provider conducts semi-annual environmental monitoring of Unit 1 based on the ANDAL Addendum and its RKL-RPL (2004). This monitoring is undertaken at several locations representing the sensitive receptors (i.e., the settlement areas of the villages/sub-villages in Bakal, Praten, Ngandam, Pawuhan, Karang Sari, Karang Tengah, Kepakisan, Simpangan, Sikunang, and Dieng Kulon). Results of 2018 ambient air quality show that levels of main pollutants such as sulfur dioxide (SO₂), nitrogen dioxide (NO₂), and total suspended particulates (dust) and lead (Pb) are below the limits set by the Government Regulation (GR) No. 41/1999 on Air Pollution Control while ambient concentrations of ammonia (NH₃) and hydrogen sulfide (H₂S) are also below the odour limits set by the Ministry of Environment Decree No. 50/1996 on Odor Standard. Ambient noise levels were monitored in the same locations as air quality and results show (i.e., last two quarters 2018) that the noise level at Sikunang (closest sensitive receptor) to Unit 1 is below the limit of 55 dB(A) for residential area set by the Ministry of Environment Decree No. KEP-48/MENLH/11/1996 on Noise Level Standard.

12. The existence of active volcanoes in Central Java and other parts of Indonesia make it as among the active seismic zone within the Pacific Ring of Fire. The seismic activity in the country resulted from the subduction zones of the Eurasian Plate, Pacific Plate, and Indo-Australian Plate, the main active tectonic plates in the world. For centuries, volcanic activities at Dieng Mountains/Plateau have been dominated by recurrent phreatic eruptions and geothermal related manifestation (i.e, fumaroles, solfataras¹, mud pools, and hot springs). The Dieng volcano is noted for its release of carbon dioxide (CO₂) and other hazardous gases, sometimes at high concentrations and prolonged exposure that could result in fatalities and destroy the surrounding vegetation (known as '*death valley*', phenomenon). Based on the Indonesia Hazard Map, the Dieng Plateau is within an area that has less hazard potential compared to other areas in Sumatera or Sulawesi.

13. The project area is crossed by several streams and rivers. There are several main seasonal streamlets, like Kali Belo and Kali Tulis in the north, Kali Dolok, Kali Sedangdang and Kali Condong on the southwestern, and Kali Merdeka on southern parts that flow into Lake Merdada. Lake Merdada is the largest natural pond in the area whose water is reportedly acidic while Warna and Pengilon are natural ponds inside a crater. There are three main rivers within the Sileri area: Sidolog river is the main river crossing the Sileri area; Urang river is located in the North of the Sileri area and Tulis river is outside the Sileri area. Irrigation water is supplied from natural lakes, ponds and streams through a dense network of small-diameter irrigation pipes installed and maintained by farmer groups.

14. The drainage system is dominated by Wonosobo and Karangobar groundwater basin. The Wonosobo basin is located at an elevation ranging from 900 masl to 1,200 masl (the project elevation ranges from about 1,800 masl to 2,000 masl). This groundwater basin is estimated to have 210 million m³ (MCM)/year of unconfined groundwater recharge and 8 MCM/year of confined groundwater flow. The Karangobar basin is located at 1,000 masl, and has unconfined groundwater recharges from about 153 MCM/year and confined groundwater flow of 4 MCM/year.

¹ Oxford Dictionary. Solfatara is a volcanic crater emitting only sulfurous and other gases.

The sources of drinking water of most of the residents are three spring locations: Sidandang, Siranti, and Situlu where water is collected in small concrete reservoir and piped to the users.

15. The project site has limited forest area as it has been extensively used by local people mainly for agriculture planted to potatoes, cabbage, carrots, pepper, Carica Dieng (*Carica candamarcensis* sp.) and other cash crops. A full Critical Habitat Assessment identified this landscape to be likely or actual Critical Habitat for: one globally Critically Endangered and two Endangered primates (Javan Slow Loris, Javan Surili and Silvery Gibbon); the Critically Endangered Javan Leopard; one Critically Endangered and one Endangered bird (Javan Green Magpie and Javan Hawk-eagle); three migratory birds of prey (Oriental Honey-buzzard, Chinese Sparrowhawk and Japanese Sparrowhawk); a restricted-range freshwater snail (*Gyraulus terraesacrae*); and the *Pengunungan* Dieng Important Bird Area.

16. The 2018 biodiversity study conducted by GDE recorded that most of Dieng Plateau are planted to vegetable crops in areas that have a slope of up to 70%. Results show that there are 163 species of flora of which 14 species are local to Dieng, 24 species associated with the presence of crater, 55 species of Java highland area, 16 economically-valuable species, and 15 introduced species of which three species are invasive. The study also identified 49 species of fauna consisting 6 species of mammals, 2 species of amphibians, 35 species of birds, and 6 species of fishes.

17. The project area has a population of about 28,000 in 2018 whose main occupation is farming. Alternative livelihoods include the development of carica and herbs as processed agricultural products, establishment of homestays and provision of tour guides to support tourism activities. The population have communal facilities for bathing, washing and toileting (public latrines) or have a toilet in their home connected to septic tank system. Diarrhea, pneumonia, and tuberculosis are among the common illnesses within the population suggesting that sanitation and personal hygiene is still a concern. Of the total medical cases treated in each district, HIV/AIDS and sexually transmitted diseases contributed to around 1.7% in Banjarnegara, 4.1% in Wonosobo, and 11% in Batang.

Anticipated Impacts and Mitigation Measures

18. The main environmental concerns for the Dieng Unit 2 facilities include air quality, noise levels, use of water for well drilling, generation of waste, potential presence of asbestos containing materials (ACM) in the existing structures at the power plant site, and occupational health and community safety risks, primarily during construction. Some of these impacts and risks are discussed below. To minimize these potential impacts, several studies will be part of the detailed engineering design (DED) as follows:

- (i) Detailed site investigation to include flood risk assessment and storm drainage analysis;
- (ii) Seismic consideration in the design will include seismic hazard study to demonstrate that the structural design of the power plant and SAGS is seismically safe for anticipated seismic risks;
- (iii) Additional water source assessment to show no adverse impacts on other water users particularly local farmers during well development, and to design and install freshwater reservoirs at Unit 2 power plant (5,000 m³) and Pad No. 24 (20,000 m³);
- (iv) Conduct hazard risk assessment on the design, storage, handling and use of butane and iso-pentane;

- (v) Noise modeling to show compliance to the International Finance Corporation (IFC)-World Bank (WB) Environmental, Health and Safety (EHS) General Guidelines 2007 values (55dB, 45dB, 3dB increment);
- (vi) Air quality dispersion modeling to show compliance to the ambient H₂S level (28µg/m³, 24-hr averaging time) and emission level (30 mg/Nm³) as required by Ministry of Environment Decree No. KEP-50/MENLH/11/1996 on Odour Level Standard and Ministry of Environment Decree No. P.15/MENLHK/SETJEN/KUM.1/4/2019 on Emission Standard of Stationary Emission Source for Thermal Power Generation;
- (vii) Improvement in the existing facilities of Unit 1 to identify and include the necessary repairs/improvements including (a) brine ponds at well pads 10 and 30; (b) silica collection and storage at well pads 7 and 30; and (c) access control to existing wells pads 7, 9, 30 and 31 including fencing gate and security guard; and
- (viii) Integrate aesthetic elements in the design.

19. Before the construction of Unit 2, demolition will be required for about six existing structures at the power plant site. Demolition works will potentially increase dust and noise levels, generate wastes and other debris, and pose occupational health and community safety risks.

20. Prior to demolition, a rapid assessment study will be done by the PMC (or a 3rd party qualified expert) to determine the presence of asbestos-containing materials (ACMs). The assessment will be one of the basis for the preparation of a demolition plan to be approved by GDE, the relevant authority, and the ADB. Removal of hazardous wastes, if any, will comply with the requirements of the GOI, the IFC-WB EHS General Guidelines 2007, and WHO on waste management. GDE has a health, safety and environment standard operating procedures (HSE SOP-037-R1) on management of hazardous and toxic wastes ("B3 wastes"). The contractor for demolition will be required to consult and/or announce to the settlements in Karang Tengah and Dieng Kulon about the schedule, activities, and the site-specific safety and work plans for the workforce, local communities, and the service vehicles.

21. To drill 11 wells for Dieng Unit 2, the water requirement is estimated to be ranging from 25,000 m³ to 55,000 m³ where the potential sources could be Cidolog River and Tulis River. However, local farmers are highly dependent on these rivers to irrigate their crops particularly during the dry season (June to September). As water-saving measures, only one well will be drilled at once. Drilling will use various water sources including condensate from Unit 1 providing 30 liters per second (lps), Tulis and Cidolok River. No water will be used from Tulis and Cidolok river during dry season, and water reservoirs will be installed at the Unit 2 powerplant (5,000 m³) and Pad No. 24 (20,000 m³). Due to water supply challenges, the power plant will be designed to use an air-cooled cooling system.

22. A noise assessment was conducted to predict ambient noise levels during well development and construction phase, and the operation phase of Unit 1 and Unit 2 (and future Unit 3) within the villages of Kepakisan, Dieng Kulon, Karang Tengah, Bakal, Pekasiran, Sikunang, Pranten, and Dieng. Results show that three noise sensitive receptors may not comply with the noise limits during well development phase. To reduce the noise levels during well testing, a mobile rock muffler will be used as silencer, and about 16 workers per rig who may be exposed to high level noise releases will be provided with personal protective equipment (PPE) such as ear muffs/plugs.

23. Well testing is done to determine the source flow rates that may be expected from the well. This releases H₂S and increased noise levels. Steam releases will be done through discharge silencers or mufflers to contain noise while workers required in the immediate area of well testing will use self-contained breathing apparatus (SCBA). Workplaces will be located upwind of the well

testing including a wind bag or any sign to show the wind direction to alert other workers away from the steam releases. Workers will be provided with mask and portable H₂S level monitors with alarm system and its use will be mandatory. To ensure safety of all workers during well testing, safety and medical personnel will be available on-site. Portable H₂S level monitors will be calibrated regularly to ensure accurate readings of the H₂S levels. Once well testing is completed and the well capped and closed, the affected area will be revegetated to restore the site.

24. Construction works for the steam above ground gathering system (SAGS) and the power plant in Karang Tengah will be sources of increased noise and dust levels due to the mobilization of equipment, materials and workers. Movements of construction vehicles and heavy equipment will increase vehicular emissions affecting ambient air quality. The increase in vehicular emission may annoy residents of Karang Tengah, Bakal, and Dieng Kulon. These vehicular movements may also pose community safety risks. Construction sites will be provided with temporary enclosures, at least 3-m high to contain dust and muffle the noise generated. Opened areas at the construction sites and access road generating dust in Karang Tengah, Bakal, and Dieng Kulon will be sprayed with water more frequently in June to September during the dry season.

25. Other measures to minimize noise and dust include: location of stockyards in Karang Tengah, Kepakisan, Dieng Kulon, and Bakal will be away from settlements and will be covered, trucks transporting dusty materials along Karang Tengah for the power plant will be covered with tarpaulin or any suitable material, service vehicles and machineries will be properly maintained, speed limit for construction vehicles will be enforced, and contractors will be required to clean up right away any mud, debris or dusty material left on public roads most importantly those stretch going to the power plant site in Karang Tengah, and area for cleaning up of vehicles onsite will be provided to ensure there is no carry over to public roads. To minimize safety risks, a staff will be designated to manage traffic and temporary crossings will be installed accommodating elderly, children, and persons with disabilities. Clear and visible warning signs will be installed.

26. The installation, connection, and closure of the underground transmission lines (UGTL) from Unit 2 to the existing substation in Unit 1 may also cause generation of dust, noise, wastes, and occupational health and safety risks within about 6.9 km stretch of the route. These activities will include stripping of vegetation, excavation, electrical, mechanical and other civil works. As a result, local residents may experience temporary disruptions of their daily activities. Heavy equipment such as backhoe will dig the trench for the pipeline. Topsoil will be re-used to backfill the trench. Once the construction activities for the UGTL are completed, the route affected will be restored to their original condition and topography. Appropriate measures to minimize dust, noise, use of PPEs, traffic management, etc. will be similarly implemented by contractors.

27. Generation of wastes during well development include mud drilling fluids. These wastes include rock cuttings, excess drilling mud and rig washings which are generally considered as non-hazardous. These wastes are left to evaporate in the sump, or to be used as water sources for subsequent drilling activities. The sumps are lined with impermeable material to prevent soil and water contamination and will be designed to accommodate the estimated volume of dry and wet cuttings. The estimated dry cuttings will be 37.8 m³ (nominal open hole volume) while wet cuttings with 10% mud will be 42.6 m³. The design of sump will also consider the intensity rainfall and frequency of rainy days in Dieng (about 68% of the year) to ensure that any overflow is accommodated. To prevent sump wall failures, berms will be compacted during sump construction as much as possible and will be inspected following construction. Sump overflow pipes will be checked for structural integrity to prevent leakage within the sump wall.

28. The use of sumps to handle drilling wastes will unlikely cause groundwater contamination as the design of sump and construction practices ensure sump location in original ground, lined, and leak-testing of sumps. After drilling, the wells will be properly cemented and cased off to prevent groundwater contamination.

29. Adequate and appropriate portable sanitary facilities will be installed at the construction sites. The estimated solid wastes that may be generated per day by workers during construction is 154 kg/day based on a generation of 0.7 kg/day/person in 2015 and assuming that the total number of workers will be 220 persons covering well drilling, construction of SAGS, power plant and access roads. The solid wastes will be temporarily collected onsite and final disposal at designated sites approved by the PMU.

30. The impacts associated to construction works for well development, power plant and support facilities, and the installation of the underground power transmission line can be considered as temporary, of short duration, and be readily mitigated by compliance to relevant regulations and good engineering construction.

31. During operation, there will be no visible white smoke from the cooling towers as the coolant will be air. However, even without the white smoke there will be continuous release of H_2S in the cooling towers. The initial results of air quality dispersion modeling during operation indicate that incremental H_2S concentrations above $150 \mu\text{g}/\text{m}^3$ (WHO standard, 2000), where the first sign of eye irritation may occur, will be contained within a radius less than 400 m. Under normal operating conditions, the threshold value for working environment (i.e., 8-hour averaging time) of $1,400 \mu\text{g}/\text{m}^3$ as set by Regulation of the Minister of Employment and Transmigration Number PER.13/MEN/X/2011 is not expected to be exceeded (with a maximum 8-hour value of $536 \mu\text{g}/\text{m}^3$ predicted over a 5-year modeling period). Workers will be provided with appropriate PPEs as part of standard operating procedures of Unit 2. Adequate ventilation will be provided in all the work areas close to the cooling towers where ambient H_2S may occur.

32. The initial assessment further concludes that there is a 0.6% probability that the 24-hour average incremental H_2S concentrations will exceed the limit for odour ($28 \mu\text{g}/\text{m}^3$). Such values are expected to occur primarily within a 400m radius of the cooling towers. The assessment concludes that in Karang Tengah, the nearest sensitive receptor, the probability that average 24-hour concentrations will exceed the limit for odour ($28 \mu\text{g}/\text{m}^3$) is 8.8% (or some 30 days per year). However, such exceedances will be very low, with probabilities that average 24-hour concentrations exceed $56 \mu\text{g}/\text{m}^3$ (i.e. double the odour standard) and $75 \mu\text{g}/\text{m}^3$ (i.e. half the WHO recommend threshold) of 2.7% and 0.4%, respectively. The model results further indicate that the 24-hour average values will never exceed the $150 \mu\text{g}/\text{m}^3$ threshold recommended by WHO in Karang Tengah, and will not exceed the limit for odor ($28 \mu\text{g}/\text{m}^3$) at the other sensitive receptors included in the assessment (i.e. Pawuhan, Kepakisan, Simpangan and Dieng Kulon). Given the climatic condition in Dieng where 8 months of the year will be rainy, this ambient H_2S level will be naturally washed out without any health effects. During the 4 months in summer where dispersion is much better, this ambient H_2S level will be dispersed downwind of the power plant farther away from the settlements.

33. During DED, the air quality dispersion modeling will be conducted again once the required information such as cooling tower height, cooling tower diameter, etc., are confirmed. During that stage, the values of ambient H_2S will be much more accurate. The modeling will be conducted to ensure that the H_2S releases will meet the emission level of $30 \text{ mg}/\text{Nm}^3$ and ambient level for odour of $28 \mu\text{g}/\text{m}^3$ (24 hour averaging time).

34. Noise will be generated also due to the operation of SAGS and the power plant. Noise modeling results indicate that compliance to the ambient limits as defined in the IFC EHS Guidelines 2007 will be achieved. Noise-generating equipment and machines like turbine will be in a confined within the respective buildings that are lined with sound absorbing walls. Workers assigned to high noise generating activities will be required to wear PPEs and will be rotated every two hours. A rock-muffler will be installed within the power plant to handle release of excess steam in case of operational problem or during excess of steam supply.

35. The air-cooled cooling tower will not generate sludge compared to the wet-cooling tower. Wastewater will mainly come from workers and staff of Unit 2 and from the laboratory resulting from the daily analyses of geothermal and environmental parameters. Septic tanks will handle domestic wastewater while laboratory wastes can be neutralized and mix with waste to injection wells.

36. The alignment of the UGTL will be monitored regularly by GDE through walk-trough survey to check for large trees that may be growing along the right-of-way (ROW). Trees and large shrubs will be removed within the ROW their roots may cause potential problems to the cables. Only some herbal vegetation and agricultural crops may be allowed to return to the ROW for safety. Appropriate visible and clear markers and warning signs will be installed along the UGTL to alert local residents of the location and what is underneath.

37. The use and storage of butane and iso-pentane may pose occupational and community safety risks. The design of the storage tank will comply with the most stringent requirements to ensure safety of settlements in Karang Tengah, Dieng Kulon, and Bakal. The storage area will have concrete bund walls as enclosure to the storage tanks. Leak and fire detection devices, fire-fighting control and alarm systems will be installed close to the storage tanks. Workers will have regular training on safe handling of these substances. Routine checks on the condition of the storage tanks, piping and gauges will be done daily and information logged in the operational data sheet. Lighting arrestors will be installed to prevent lightning strikes. GDE will conduct annual fire drills involving the selected representatives of the communities of Karang Tengah, Dieng Kulon, and Bakal who will serve as fire marshals for the community. GDE has an emergency preparedness and response procedures following the requirements of ISO 14001. GDE staff will have regular training on emergency preparedness including the proper handling and storage of these substances. GDE will develop a protocol in this regard.

38. Local communities perceive that atmospheric corrosion affecting their housing structures is coming from GDE operations. With the operation of Unit 2, this perception may continue creating anxiety and uncertainties among the local residents. Geothermal power generation does not generate nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) the main causes of acid rain. A remarkable volcanic feature is shown by the Dieng Plateau in Central Java, which has “*kawah upas*” or the death valley due to the high concentration of CO_2 . CO_2 reacts with water in the atmosphere to form carbonic acid (H_2CO_3), a weak acid. Dieng has about 2,700 mm per year of rainfall with rainy days of about 68% of the year. Normal rain has a pH of about 5.6; it is slightly acidic because of the carbonic acid.² The weak carbonic acid progressively attacks the roof and the structures every year with the heavy rainfall eight months of the year in Dieng. GDE will continue consultations with the communities to explore opportunities for assistance.

² <https://www.epa.gov/acidrain/what-acid-rain>.

39. Decommissioning can be during well development or after the end of the economic life of Unit 2. Should there be a need for decommissioning during well development, sump that was used will be backfilled with previously stripped topsoil which is kept reserved; revegetation will be done after backfilling; and the well pad will be capped, secured, and maintained for monitoring purposes. Reusable items and equipment will be stored and used with other similar projects. If decommissioning will be at the end of the economic life, a decommissioning plan will be prepared following the EHS requirements of Indonesia and ADB. Consultations will be conducted to the villages in Karang Tengah, Dieng Kulon, Bakal, Kepakisan, Pranten and Sikunang will be conducted during the preparation of the decommissioning plan.

40. Beyond compliance GDE has a suite of health, safety, and environment (HSE) standard operating procedures recognized by the ISO 14001:2015 on the Environmental Management System for their power plant and steam field operations for Unit 1 valid until 26 December 2019. A similar initiative will be undertaken for Unit 2.

Analysis of Alternatives

41. A “no project” option entails that the expected contribution to increase the current installed capacity of geothermal power will not be realized. It will also negate the need to meet the GOI target of 6.3 GW from geothermal energy by 2026.

42. Geothermal resource is site-specific and power plants must be located close to the geothermal source. This constraint reduces the choices for an efficient location of the power plant. Based on previous studies by experts, the Dieng geothermal field can accommodate about 400 MW of commercial viability. Dieng Unit 2 will be located about 3 km north west of Unit 1 on an elevated land of about 6 hectares.

43. Dieng 2 will contribute 55 MW to the national target of 7% geothermal. Compared to other renewable energy such as wind and solar, the geothermal source can provide a reliable baseload power. Geothermal energy utilization is not affected by climate change compared to hydropower and will not be affected by changes in prices of fossil fuels. Geothermal is the only renewable energy with a potential capacity factor of more than 80% with some plants recorded a capacity factor of 90%, higher than fossil-fuel fired power plants. As well, land requirements is lesser compared to hydropower with storage or coal-fired power plants.

44. Renewable energy utilization through geothermal power development is consistent with the Energy Policy 2009 of ADB where promoting energy efficiency and renewable energy is one of the pillars of policy implementation.

45. Water is predominantly used for cooling in geothermal power plants which is generally through closed-loop (recirculating) cooling systems. This system withdraws and consumes water, but not all water withdrawn is consumed. Small amount of water lost through evaporation is replaced as make-up water. While this type of cooling is closed-loop, it will require substantial amount of water. Given the limited water supply in Dieng, an air-cooled cooling system will be used.

46. The initial option in evacuating the power generated from Unit 2 to the existing substation in Unit 1 is overhead transmission line consisting of 12 transmission towers. The results of the critical habitat assessment show that migratory birds of conservation status would be adversely affected potentially causing mortalities. Given all environmental and social considerations, the selected option will be a 6.9 km, 150 kV underground transmission line.

Information Disclosure, Consultation and Participation

47. Two consultation events were conducted in March 2019 and September 2019 attended by a total of 391 persons consisting of 270 men (69%) and 121 women (39%). Participants were invited by GDE through their village head and consultations were held in the village community centers. Consultations begin with the national anthem followed by a prayer and welcome address by the village head. GDE staff presented the overview of the project while ADB staff explained the safeguards requirements of ADB. Participants were requested to sign in the attendance sheet prepared by GDE. The consultations were done in Bahasa. Targeted consultations were also done from March to August 2019 to institutions such as WWF Indonesia, *Wahana Lingkungan Hidup Indonesia* (WALHI), and individual experts on biodiversity.

48. Issues raised by the participants include community health and safe during construction particularly the mobilization of equipment and vehicles at nighttime, poaching of wildlife, waste management, lack of community awareness to the emergency preparedness and response. GDE assured the communities of their compliance to the national regulations and to ADB.

49. Consultations will continue during the project implementation. A communication strategy plan was prepared to provide guidance to GDE in effective stakeholder engagement. Information, education, communication (IEC) initiatives will be mapped by GDE as an important tool to forge good relationships with the communities as partners in geothermal power development. A project summary in Bahasa will be posted on the GDE website, a flyer in Bahasa about project brief which will include details on the grievance redress mechanism (GRM) will be made available at Dieng office, GDE office in Jakarta, and the village offices. A simple Q & A flyer/brochure also in Bahasa about the potential impacts, mitigation measures, and benefits from geothermal energy utilization will be prepared and made available to schools, government offices, and interested individuals within the project area in Karang Tengah, Dieng Kulon, Bakal and Kepakisan.

Grievance Redress Mechanism

50. A GRM will be established by the PMU to deal with complaints from affected persons that may be raised during project implementation. Complainant can seek redress through a three-tier entry points: (i) at the project level through the PMC or representative of the Contractor; (ii) at the PMU level through the grievance redress committee (GRC); and, (iii) the MOEF or the appropriate courts of law. Members of GRC will include the Head Office General Project Manager and the HSE Manager of the PMU, the head or representative from the village (*kecamatan*), the Site Office Project Manager, Public Relations staff and Environment Staff from the HSE and Safeguards Unit in Dieng, the PMC, and a representative of the Contractor(s). The PMC will act as the secretariat of the GRC. GDE will ensure fair representation of women in the GRC and to observe transparency in handling complaints at all times. The GRC will be responsible for resolving complaints (if any) within a month (30 calendar days) from the date it was received, to maintain a record of complaints received and resolved, and to advise the complainant on the decision made. The PMU (through the PMC) will create a database of complaints filed and resolved.

51. Complaints can be filed by phone call, walk-in or in person while written complaints could be through mail/letter, comments/suggestions drop-box, GDE website, email, or fax. Procedures to file a complaint and the details of the GRM Focal Person will be disclosed by the PMU to the affected communities prior to the start of construction works and more detailed information on the GRM will be posted on billboards at the construction sites. A hotline phone number that will work

24/7 and a simplified flowchart on how to file a complaint will be disclosed to the affected communities before construction works start.

52. The summary of grievances filed and resolved will be included in the semi-annual environmental monitoring reports submitted by GDE to ADB. The associated costs to maintain the GRM will be borne by GDE. The complainant is not restricted to seek redress through the legal system at any point in the GRM process.

Environmental Management Plan

53. An environmental management plan (EMP) was developed to identify the potential environmental impacts and defines mitigation measures and monitoring requirements for the pre-construction, construction, and operational stages of the project. It also defines the institutional arrangements and mechanisms, the roles and responsibilities of different institutions, procedures and budgets for implementation of the EMP. The EMP seeks to ensure environmental protection activities during pre-construction, construction, and operation, continuously improve to prevent, reduce, or mitigate the adverse environmental impacts and risks.

54. The EMP is based on the Feasibility Study August 2019 as DED is yet to be initiated, and will be done by the PMC for the civil and enabling works (access roads, water supply, etc.) and for drilling works; and by the EPC Contractor for the design, supply, construction, commissioning and testing of the power plant and SAGS facilities.

55. Environmental monitoring will be done regularly based on the requirements of the AMDAL and SPS 2009. A variety of monitoring methods can be used from ocular inspection/spot checking sampling, and analysis. Important aspects to be monitored will include noise (ambient and occupational level), air quality (ambient and H₂S emission), water quality (freshwater, rainwater, and groundwater), generation and handling of waste, restoration/revegetation of opened, etc.

Conclusion and Recommendation

56. GDE has embarked on Dieng Unit 2 to contribute in the goal of GOI to meet the 7% share of geothermal in the national energy mix by 2025, at the same time, supporting the commitment in COP21 to reduce GHG emissions at 29% by 2030. Implementation of Dieng Unit 2 will also help achieve the national target for 100% electrification by 2020.

57. Additional studies were conducted as part of the IEE: air quality and noise modeling, critical habitat assessment, and a separate safety risk assessment. As a result of the critical habitat assessment, the design of the transmission line route was changed from an overhead transmission line to underground cable as this change will have no effect to migratory birds of conservation status. Unit 2 will use air-cooled cooling system to avoid using water. This will not have adverse impact on the water uses of the communities. Noise assessment shows that there will be four stations that may not meet the daytime limits of GOI and the IFC-WB EHS Guidelines 2007 during well development, and construction of Unit 2 while air quality dispersion modeling study shows that there is a 8.8% probability that the 28 µg/m³ H₂S odour limit of GOI will not be met in Karang Tengah.

58. A more detailed assessment of noise and air quality will be done during DED to ensure compliance during well development, construction, and operation. The quantitative risk assessment and review of the emergency preparedness and response system including the

environmental management system of GDE showed compliance to SMK3, ISO 14001, and OHSAS 18001 but some improvements on safety need to be implemented. It was recommended to develop protocol to involve communities in emergency preparedness drills. Two public consultations were done and GDE will continue to engage the communities on the safe and beneficial use of geothermal energy available in Dieng.

59. There are associated impacts during well development, construction, and operation of Dieng Unit 2 on noise, air quality, water use, and generation of wastes. However, these impacts can be readily mitigated through design, employing best available technology, good engineering construction methods, effective stakeholder engagement (as and when needed), compliance to EMP and environmental monitoring, and compliance to applicable regulations and standards on geothermal power plant operations, and environmental, health, and safety. GDE has a suite of health, safety, and environment standard operating procedures to provide guidance in implementing Dieng Unit 2 sustainably.

1 INTRODUCTION

60. The population of Indonesia in 2018 was about 264.2 million compared to about 261.4 million in 2017.³ Associated with increase in population is demand for electricity. With the current generating capacity of 60.7 gigawatt (GW), Indonesia struggles to keep up with electricity demand in many parts of the country that blackouts remain common in some areas like Sumatera, Kalimantan, Sulawesi, and Eastern Indonesia.⁴

61. Indonesia is an archipelago consisting of more than 18,000 islands and is located within the Pacific Ring of Fire where most of the world's geothermal activity is known to occur. Given its geographical location, Indonesia has about 40% or 28,617 megawatt (MW) of the world's geothermal energy potential (71,543 MW) but only 4.5% has been utilized (Figure 1.1).⁵ Geothermal power is a clean source of energy and compared to other types of renewable energy, it can be used as baseload to provide a reliable source of energy. As well, geothermal resources are not dependent on climate conditions and are not expected to be affected by climate change compared to hydropower.⁶ Geothermal power systems generate less carbon dioxide (CO₂) emissions unlike power plants burning coal and natural gas.⁷



Figure 1.1: Geothermal Energy Potential

62. As of 2018, the energy mix in Indonesia is predominantly coal (61.94%) followed by natural gas (20.85%) and less than 10% contributions from hydropower (6.94%), geothermal (5.37) and oil (4.24%). Other types of renewable energy (i.e., solar, wind, biomass, etc.) contribute to less than 0.5%.

63. In October 2014, the Government of Indonesia (GOI) enacted Government Regulation No. 79 of 2014 on the National Energy Policy ("2014 NEP"). Some highlights of 2014 NEP include: (i) increase installed capacity for power generation of 115 GW by 2025 and 430 GW by 2050; (ii) reach per capita electricity consumption of 2,500 kWh by 2025 and 7,000 kWh by 2050; and (iii) attain close to 100% electrification ratio by 2020.

³ <https://tradingeconomy.com>

⁴ PWC. Power In Indonesia. Investment and Taxation Guide. November 2018, 6th Edition. www.pwc.com/id.

⁵ Think GeoEnergy (2019), GEA (2016), and IGA (2015).

⁶ Intergovernmental Panel on Climate Change. Special Report on Renewable Energy Sources and Climate Change Mitigation. June 2011.

⁷ Geothermal Energy Association. Geothermal Basics. http://geo-energy.org/geo_basics_notes.aspx#environment.

64. The 2014 NEP targets a national energy mix from new and renewable energy sources to 23% by 2025 and 31% by 2050. The 23% goal from renewable energy consists of bioenergy (10%), geothermal (7%), hydropower (3%), and other new and renewable energy sources (3%). With these targets, contribution from geothermal energy will be increased to 5.8 GW from the present 1.8 GW generation capacity.

65. During the 2015 Conference of Parties in Paris (COP21), Indonesia committed to a Nationally Determined Contribution at 29% reduction in GHG emissions by 2030.^{8,9} To meet this commitment, Indonesia needs to expand utilization of renewable energy mainly through geothermal power generation but this initiative requires huge investments.

66. To support the goal of GOI in meeting its commitment to COP21 and advancing the targets of 2014 NEP, P. T. Geodipa Energi (GDE) requested the Asian Development Bank (ADB) to provide financing of additional geothermal generation capacity of 110 MW for Dieng Unit 2 (55 MW) in Wonosobo, Central Java and Patuha Unit 2 (55 MW) in Ciwidey, West Java (Figure 1.2).



Figure 1.2: Location of the Project

67. Established on 5 July 2002, GDE has developed geothermal fields in Dieng (Unit 1 at 55 MW) and the Patuha (Unit 1 at 55 MW) which started commercial operation in 2014. GDE was initially established as an entity jointly owned by PT *Perusahaan Listrik Negara* (PLN) and Pertamina (now PT Pertamina Geothermal Energy or PGE), but in December 2011, GDE has been set-up as a state-owned-enterprise.

68. The Dieng-Patuha expansion project is included in the Fast Track Program which is a flagship program of GOI in electricity infrastructure development. The expansion is also identified in the National Strategic Program for Electricity Supply Business Plan (*Rencana Umum Penyediaan Tenaga Listrik* or RUPTL) 2019-2028 as needed in order to achieve the target of 7.2

⁸ https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/Indonesia/1/INDC_REPUBLIC%20OF%20INDONESIA.pdf

⁹ 2015 United Nations Climate Change Conference, COP 21 or CMP 11 was held in Paris, France on 30 November 2015 to 12 December 2015 and was the 21st annual session of the Conference of Parties (COP) to the 1992 United Nations Framework Convention on Climate Change and the 11th session of the Meeting of the Parties (CMP) to the 1997 Kyoto Protocol.

GW geothermal capacity by 2025 presented in the National General Energy Plan (*Rencana Umum Energi Nasional* or RUEN) of the Ministry of Energy and Mineral Resources (*Kementerian Energi dan Sumberdaya Mineral*).

69. GDE is committed to environmental protection and management in its geothermal power generation facilities and has received the following citations and accreditations:

- 'PROPER' award with 'blue' rating from the Ministry of Environment and Forestry (MOEF) from 2015 to 2017. PROPER¹⁰ is the program of the MOEF to encourage companies in complying with environmental laws and regulations and in providing a recognition mechanism to sound environmental management performance. Blue rating means that GDE has complied with prevailing environmental laws and regulations as the minimum requirements on, among others, water management and pollution control, hazardous waste management, air pollution control, and implementation of environmental impact assessment.
- ISO 14001:2015 certification No. EMS 00259 (valid until 26 December 2019) on the Environmental Management System for their power plant and steam field operations.
- The Subroto Award in 2017 on Geothermal Environmental Protection (Production Geothermal Area) with Category: PRATAMA from the Minister of Energy and Mineral Resources.

1.1 Overview of the Project

70. The proposed geothermal power generation project will support expansion of Indonesia's geothermal generating capacity to contribute to the sustainability and sufficiency of the electricity system, and also aligned with the UN Sustainable Development Goal 7 of ensuring access to affordable, reliable, sustainable and modern energy for all.¹¹ Table 1.1 presents the project details while Table 1.2 gives the financing plan.

Table 1.1: Project Details

Output	Description
Output 1: Geothermal power plants constructed and commissioned	<p>GDE to commission a 55 MW geothermal power plant at Dieng, Central Java Province and another 55 MW geothermal power plant in Patuha, West Java Province. Both the geothermal power plants will include well development for production and reinjection, development of steam above ground gathering system (SAGS), and fluid reinjection lines connecting wells. Patuha will have one single-flash power plant and Dieng will have a combined cycle plant with both steam and Organic Rankine Cycle (ORC) turbines.</p> <p>The project will also support the power transmission interconnection systems between the plants and the grid; at Dieng, this will include a new, 6-km 150 kV underground transmission line to the Dieng Substation whereas Patuha will use existing towers to connect to the Patuha Substation.</p>

¹⁰ PROPER is Program for Pollution Control, Evaluation, and Rating launched in 1995 with support from the World Bank, USAEP/USAID, and Canadian and Australian development agencies.

http://siteresources.worldbank.org/INTEPOWERMENT/Resources/14825_Indonesia_Proper-web.pdf.

¹¹ <https://sustainabledevelopment.un.org/sdg7>.

Output	Description
Output 2: Institutional capacity of GDE strengthened.	Strengthen GDE's capacity to plan for, develop, and operate geothermal power plants, including management of complex technical conditions, multiple coordinated contracts, and environmental risks.
Output 3: Partnership and community development program improved.	Enhancement of GDE's Community Development Program through more strategic engagement with the communities and evaluation of programs that can most meaningfully contribute to improved well-being.

Table 1.2: Financing Plan

Source	Amount (\$ million)	Share of Total (%)
Asian Development Bank		
Ordinary capital resources (regular loan)	280.00	59.9
Clean Technology Fund	20.00	4.3
Geo Dipa Energi	167.51	35.8
Total	467.51	100.0

Sources: ADB and GDE estimate.

1.2 Project Implementation Arrangements

71. The project is expected to be implemented from 2020-2024. GDE will be the executing agency (EA) and will be responsible for the overall supervision and management of project implementation. As the EA, GDE will ensure the following:

- (i) Availability of adequate and timely counterpart funding and approval of higher authorities for project activities;
- (ii) Establish a project management unit (PMU) with required number of staff and appropriate qualifications;
- (iii) Coordinate with relevant ministries to ensure smooth project implementation; and,
- (iv) Ensure timely execution of procurement and consultant recruitment, including the provision of necessary approvals.

72. A project management unit (PMU) will be established by the GDE. The PMU will be responsible for the overall day-to-day management and supervision of project activities in coordination with the project management consultant (PMC). The PMC will be engaged to provide technical support to the PMU in carrying out their project management functions. The PMU will ensure compliance to the environmental requirements of ADB according to their Safeguard Policy Statement (SPS) 2009. The SPS 2009 embodies the environmental requirements and review procedures of ADB for all the projects and grants they finance. Figure 1.3 presents the project management arrangements.

73. The PMU will have an environmental safeguard staff both in the Head Office in Jakarta (i.e., head office-based) and the Dieng Unit 2 (i.e., site-based). At the Jakarta Office, the Environmental Safeguard Assistant Manager will report to the Health, Safety, and Environment (HSE) Manager and both staff will report to the General Project Manager of the PMU. In Dieng Unit 2, the Environmental Safeguard Supervisor will report to the HSE & Safeguard Superintendent. Both site-based safeguard staff are under the supervision of the Project Manager. These environmental safeguard staff will provide the technical support to the PMU in ensuring compliance to the environmental requirements of ADB.

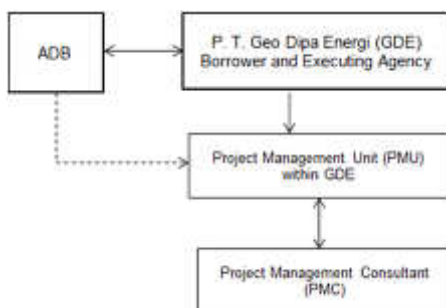


Figure 1.3: Project Management Arrangements

1.3 The Need for Environmental Assessment

1.3.1 National Requirements

74. Approved on 3 October 2009, Law No. 32 on *Environmental Protection and Management*, among others, require that every business and/or activity that causes substantial impact on the environment shall be subject to the environmental impact assessment (EIA) process (*Analisis Mengenai Dampak Lingkungan* in Indonesia or AMDAL).

75. Following the national requirements, the ANDAL (or EIA study) Addendum 2004 was approved by the MOEF for Dieng Geothermal Power Plant covering Unit 1, Unit 2, Unit 3 and Unit 4. However, Unit 2 will use a more advanced and efficient power plant technology to minimize the potential environmental impacts. Given this major change, another ANDAL Addendum will be required as provided for by GR No. 27 of 2012. GDE is in the process of engaging an MOEF-accredited and certified environmental expert to prepare the Addendum.

1.3.2 Environmental requirements of ADB

76. The Safeguard Policy Statement (SPS) 2009 of the Asian Development Bank sets out the requirements for environmental safeguard that applies to all ADB-financed projects and grants.¹² Under SPS 2009, projects or grants are screened and categorized based on their potential environmental impacts. Following the classification of SPS 2009, Dieng Unit 2 is category B for environment requiring the preparation of an initial environmental examination (IEE). A category B project is considered likely to have adverse environmental impacts that are less adverse, site-specific, few if any of them irreversible, and in most cases mitigation measures can be more readily designed. The format of environmental assessment is given in SPS 2009, Annex to Appendix 1, pp. 41-43.

SPS 2009 and the Access to Information Policy 2018 (AIP 2018)¹³ provide for the requirements of disclosure of project information from projects and grants funded by ADB. As required by SPS 2009 and AIP 2018, the IEE for Dieng Unit 2 will be disclosed to the website of ADB.

¹² Asian Development Bank Safeguard Policy Statement (SPS 2009), <http://www.adb.org/documents/safeguard-policy-statement>.

¹³ <https://www.adb.org/sites/default/files/institutional-document/450636/access-information-policy.pdf>

1.4 IEE Methodology

77. **Objectives** Conducting the IEE for the project aims to (i) describe the existing environment; (ii) conduct consultations of key stakeholders; (iii) assess the potential environmental impacts; (iv) identify the mitigation and/or enhancement measures corresponding to the potential environmental impacts identified; (v) describe the environmental management and monitoring plan to be implemented and complied with; (vi) identify a grievance redress mechanism that is culturally-appropriate, transparent, readily accessible to affected persons, and consistent to international best practices; and, (vii) ensure that all the statutory regulatory requirements relevant to the project have been identified and considered to ensure an understanding of what needs to be complied with during implementation.

78. **Scope** This IEE was prepared following the requirements of SPS 2009. The scope covers the general existing environmental profile of the project site, assessment of potential environmental impacts during design and/or pre-construction, construction, operation, and decommissioning of the project; a description of the grievance redress mechanism to address potential complaints due to the project; a description of stakeholders' engagement; and, a description of the environmental management plan (EMP) and environmental monitoring plan (EMoP). The following steps were considered:

- (i) Conduct site visits to collect relevant data and information needed to describe the to establish the baseline environmental condition;
- (ii) Compare the environmental safeguard requirements of the government and ADB, and identify the gaps and measures to bridge the gap, if any;
- (iii) Assess the potential impacts due to location, design, well development, construction of steam above ground system and power plant, operation of power plant, and decommissioning;
- (iv) Examine opportunities for environmental enhancement and identify measures;
- (v) Prepare an EMP outlining the measures to mitigate potential environmental impacts including the institutional arrangements;
- (vi) Identify key environmental parameters required to be monitored, sampling stations, frequency, and responsibility during project implementation and prepare an EMoP;
- (vii) Carry out meaningful consultation with affected stakeholders to identify perceptions of the project, introduce project components, potential impacts, mitigation measures, monitoring, and grievance redress mechanism; and
- (viii) Disclose the draft IEE in ADB website and prepare project brief and/or FAQs in Bahasa that can be publicly available at the offices of GDE in Jakarta and Patuha, and also at the construction site.

79. Field visits were conducted intermittently between February 2019 to September 2019 to conduct ocular inspection, collect primary and secondary data, public consultations, and coordinate with relevant agencies of the government and other relevant organizations like the World Wildlife Fund for Nature, and *Wahana Lingkungan Hidup* Indonesia (WALHI), an Indonesian Forum for the Environment.

80. This IEE covers the Dieng Unit 2 (1x55 MW) in Karang Tengah, Banjarnegara, Central Java.

2 Policy, Legal, and Administrative Framework

2.1 National environmental requirements

81. The following presents the relevant regulatory agency, process, regulations, standards, and international environmental agreements applicable to the project.

2.1.1 Environmental Agency

82. The Ministry of Environment and Forestry (MOEF) is the main government agency responsible for national environmental policy and planning in Indonesia. Based on the current legal framework set by Law 32 of 2009 and Government Regulation (GR) No. 16 of 2015, MOEF is the central level ministry mandated to deal with all issues on environment and forestry. The MOEF directs policy implementation, provides technical guidance and support on environmental management and protection, and oversees sectoral ministries and provincial environment authorities. MOEF has designated environmental offices at the provincial and district levels to ensure effective implementation of environmental regulations, policies, and programs.

83. With the Ministry Regulation (*Permen*) LHK 18/Men LHK-II of 2015, the *Analisis Mengenai Dampak Lingkungan* (AMDAL) is under the Directorate General of Forest Planning and Environmental System (*Direktorat Jenderal Planologi dan Tata Lingkungan* or PKTL) and is responsible for administering the formulation and implementation of consolidated policy on forest and environmental sustainability. The Directorate of Prevention for Environmental Impact of Business and Activities (MOEF) is responsible for AMDAL system development and implementation. Under the Directorate is the Sub-directorate of Application for AMDAL, environmental management and monitoring measures (UKL-UPL), and environmental permit. With the decentralization of AMDAL, implementation authority is shared with the provincial and district level environment agencies but the Sub-directorate has the key role in prevention of environmental impacts at national level. The provincial district level AMDAL under the Provincial environmental agency (*Badan Lingkungan Hidup* or BLH) is responsible to province and district environmental agencies while district BLH is responsible for AMDAL in respective district only.

2.1.2 Environmental regulations

84. National environmental regulations require that all projects need to meet the assessment and permitting procedures provided by Law No. 32 on *Environmental Protection and Management* approved on 3 October 2009. This regulation requires, among others, that every business and/or activity that causes substantial impact on the environment shall be subject to the EIA process (or AMDAL). The criteria for substantial impact include the following:

- (i) quantity of population to be affected by the business and/or activity plan;
- (ii) size of distribution area of impact;
- (iii) intensity and duration of Impact;
- (iv) environmental components to be affected;
- (v) cumulative characteristic of impact;
- (vi) whether Impacts reverts or not; and/or,
- (vii) other criteria in accordance with developments of science and technology.

85. The AMDAL process begins with the preparation of the terms of reference (TOR) of the EIA (known as *Kerangka Acuan Analisa Mengenai Dampak Lingkungan* or *Ka AMDAL*) which is

approved by the AMDAL Valuation Committee. Aside from the TOR, other documents required include the EIA study (*Analisis Dampak Lingkungan* or ANDAL), environmental management plan (*Rencana Pengelolaan Lingkungan* or RKL), environmental monitoring plan (*Rencana Pemantauan Lingkungan* or RPL), and the Executive Summary (*Ringkasan Eksekutif*). However, GR No. 27 of 2012 no longer requires the Executive Summary as part of the AMDAL documents. If parameters of the business and/or activity change, AMDAL must be renewed.

86. Article 4 of GR No. 27 of 2012 requires that the location of an activity should comply with the prevailing spatial plan and not be located in prohibited areas such as legally protected areas, with some particular exceptions. This requirement is consistent with Law No. 26 of 2007 on Spatial Planning Regulation to consider spatial analysis during impact assessment.

87. For business and/or activities that are not required to have AMDAL but which still have an impact to the environment, documents required are Environmental Management Effort (*Upaya Pengelolaan Lingkungan* or UKL) and Environmental Monitoring Effort (*Upaya Pemantauan Lingkungan* or UPL). Governors or regents/mayors stipulate the types of business and/or activities that should have UKL and/or UPL. In case a parameter of business and/or activities changes, UKL and/or UPL must be renewed (details to be issued through ministerial regulation).

88. For business and/or activities which are not obliged to have AMDAL or UKL and/or UPL must have a statement letter regarding “ability for managing and monitoring the environment”. The document required is a Statement of Environmental Management and Monitoring Undertaking (*Surat Pernyataan Kesanggupan Pengelolaan dan Pemantauan Lingkungan* or SPPL). The details of the SPPL are issued through a ministerial regulation.

89. The Ministry of Environment Regulation No. 16 of 2012 regarding Guidance on Environmental Documents Preparation (*Permen LH 16/2012*) prescribes how to prepare the environmental documents which includes the AMDAL, UKL-UPL and SPPL. AMDAL and UKL-UPL are key documents required in securing the environmental permit. The regulation provides guidance to project proponents on detailed description of environmental documents to be prepared.

90. The Ministry of Environment Regulation No. 5 of 2012 on Types of Business and/or Activity Requiring AMDAL (*Permen LH 5/2012*) is the screening process to determine if a project or activity will be subject to AMDAL or will be subject to a less comprehensive requirement (either UKL-UPL or SPPL). Based on this regulation, geothermal power development that will be subject to AMDAL are:

- (i) Geothermal work area (*Wilayah Kerja Panas Bumi/WKP*) \geq 200 ha;
- (ii) Open area for geothermal operation \geq 50 ha; and,
- (iii) Geothermal energy development capacity \geq 55 MW.

91. In terms of disclosure of public information, Law No. 14 of 2008 on Disclosure of Public Information, which was enacted on 1 May 2010, requires government institutions to provide access to information to communities including MOEF. Subsequently, Ministry of Environment Regulation No. 17 of 2012 on Community Participation and Information Disclosure (*Permen LH No. 17/2012*) requires equal and inclusive consultations of all affected people, both women and men including marginal tribes and other vulnerable groups.

92. To address grievances, the Minister of Environment Regulation No. 09 of 2010 on Procedures of Complaint and Complaints Handling due to Allegations of Environmental Pollution

and/or Damage (*Permen LH 9/2010*), requires the establishment of an Environmental Complaint Post (*Pos Pengaduan LH* or ECP) in the environmental management agencies to receive and respond to complaints about pollution and/or environmental deterioration.

93. In securing the environmental permits, the following regulations will provide guidance to project proponents:

- (i) Government of Indonesia (GOI) Regulation No. 27 of 2012 on Environmental Permit was designed to streamline AMDAL procedures;
- (ii) Ministry of Environment Regulation No. 17 of 2012 on Guidelines for Public Involvement in Environmental Assessment and Environmental Permitting Process provides the rationale for public participation in the AMDAL and in environmental permitting, identifies the communities that need to be involved in the process, and their representation in the AMDAL Appraisal Committee;
- (iii) Ministry of Environment Regulation No. 07 of 2010 on Competencies Certification of AMDAL Documents Preparation and Requirements of Training Institute for Competencies of AMDAL Documents Compiler provides for the competency requirements and certification, registration, and training of AMDAL preparers;
- (iv) Ministry of Environment Regulation No. 8 of 2013 on Evaluation and Examination of Environmental Documents and Issuance of Environmental Permit provides guidelines for the examination of documents in relation to administrative, project stage, and document quality; and,
- (v) Ministry of Environment Decree No. 45 of 2005 on Guidelines for Preparation of RKL and RPL.

94. The environmental permit issued can be cancelled if the following occurs:

- (i) The information shown in the application is incorrect or falsified;
- (ii) failure to comply with the conditions set in the AMDAL, UKL and/or UPL; or
- (iii) Decision by the administrative court.

95. Figure 2.1 shows the simplified flowchart of securing the environmental permit through the AMDAL process.

96. Following the national requirements, the AMDAL Addendum 2004 approved by the MOEF for Dieng Geothermal Power Plant covered Unit 1, Unit 2, Unit 3 and Unit 4. However, Unit 2 will use a more advanced and efficient power plant technology to minimize the potential environmental impacts. Given this major change, another AMDAL Addendum will be required as provided for by GR No. 27 of 2012. GDE is in the process of engaging an MOEF-accredited and certified environmental expert to prepare the AMDAL Addendum.

2.1.3 Other applicable regulations

97. Table 2.1 presents a non-exhaustive list of applicable national regulations which cover environmental standards and procedures of relevance to the project.

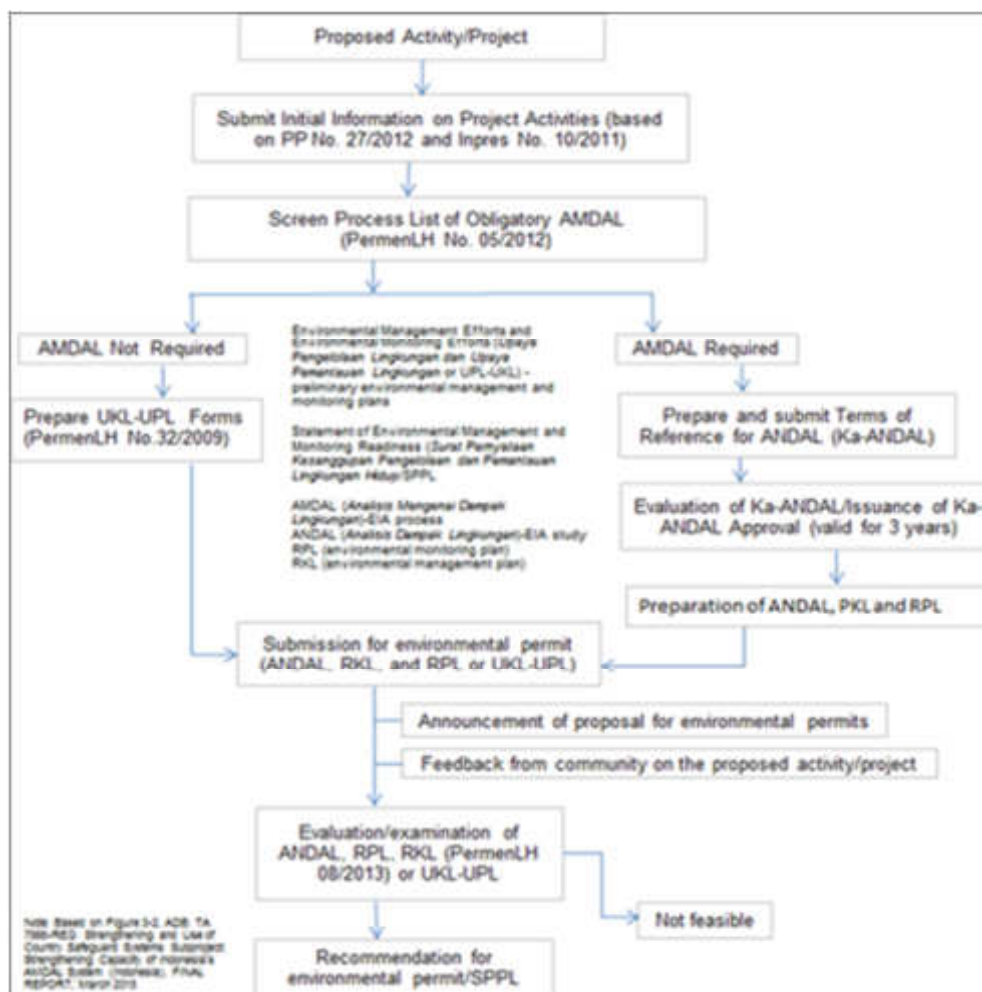
Table 2.1: Other Applicable National Regulations

Laws
Law No. 1 of 1970 on Work Safety Act

Law No. 5 of 1990 on Conservation of Natural Resources and its Ecosystems
Law No. 41 of 1999 on Forestry (amended by Law No. 19 of 2004)
Law No. 7 of 2004 on Water Resources
Law No. 18 of 2008 on Waste Management
Law No. 36 of 2009 on Health
Law No. 22 of 2009 on Traffic and Road
Law No. 11 of 2010 on Cultural Conservation
Law No. 21 of 2014 on Geothermal
Law No. 37 of 2014 on Land and Water Conservation
Government regulations
GR No. 41 of 1999 on Air Pollution Control
GR No. 74 of 2001 on Hazardous Material Management
GR No. 82 of 2001 on Water Quality Management and Waste Pollution
GR No. 76 of 2008 on Forest Rehabilitation and Reclamation
GR No. 43 of 2008 on Groundwater
GR No. 10 of 2010 on Procedures for Changing of Forest Use and Function
GR No. 24 of 2010 on Forest Area Utilization
GR No. 50 of 2012 on the Implementation of Safety and Occupational Health Management System
GR No. 81 of 2012 on Management of Domestic Waste and Similar Type
GR No. 101 of 2014 on Hazardous and Toxic (B3) Waste Management
GR No. 104 of 2015 on Procedures for Changing of Forest Use and Function
GR No. 21 of 2017 on Management of Drilling Mud and Drilling Cutting Waste from Geothermal Drilling
Ministry regulation and decree
Ministry of Health Regulation No. 528 of 1982 on Groundwater Quality Related to Health
Ministry of Transportation Decree No. 69 of 1993 on Freight Transport on the Road
Ministry of Environment Decree No. KEP-48/MENLH/11/1996 on Noise Level Standard
Ministry of Environment Decree No. KEP-49/MENLH/11/1996 on Vibration Level Standard
Ministry of Environment Decree No. KEP-50/MENLH/11/1996 on Odour Level Standard
Ministry of Environment Decree No. 37 of 2003 on Surface Water Quality Analysis Method and Sampling
Ministry of Environment Regulation No. 13 of 2007 on the Requirements of Wastewater Injections for Oil and Gas as well as Geothermal Business and/or Activity
Ministry Forestry Regulation No. 12 of 2009 on Forest Fire Control
Ministry of Environment Regulation No. 18 of 2009 on Obtaining Permits for Storage, Treatment and Disposal of Hazardous Waste
Ministry of Health Regulation No. 492 of 2010 on Drinking Water Quality
Ministry of Internal Affairs Regulation No. 33 of 2010 on Guidelines for Waste Management
Ministry of Environment Regulation No. 19 of 2010 on Wastewater Quality Standards for Oil and Gas including Geothermal Business and/or Activity
Ministry of Manpower and Transmigration Regulation No. 13 of 2011 on Physical and Chemical Factors Threshold at Workplace
Ministry Forestry Regulation No. 4 of 2011 sets the Guidelines on Forest Reclamation
Ministry of Environment Regulation No. 14 of 2013 regarding Symbols and Labeling of Hazardous and Toxic Waste
Ministry of Environment Decree No. 55/MENLH/2013 on Wastewater Discharge Standards
Ministry of Environment and Forestry Regulation No. 101 of 2014 on Hazardous and Toxic Waste Management
Ministry of Public Works and Settlements No. 50 of 2015 on Water Resources Utilization Permit
Ministry of Manpower Regulation No. 12 of 2015 regarding Electrical Safety and Health
Ministry of Environment and Forestry No. 50 of 2016 regarding Guidelines on Borrow-Use of Forest Area
Ministry of Environment and Forestry Regulation No. P.46/Menlhk/Setjen/Kum.1/5/2016 on The Utilization of Geothermal Environmental Services at National Parks, Grand Forest Parks, and Nature Recreation Parks

Ministry of Environment Decree No. P.15/MENLHK/SETJEN/KUM.1/4/2019 on Emission Standard of Stationary Emission Source for Thermal Power Generation

Figure 2.1: Simplified Flowchart of Environmental Permitting Process



2.1.4 Applicable Environmental Standards

98. Aside from compliance to national environmental standards, the SPS 2009 provides that during project implementation, GDE will apply pollution prevention and practices that are in line with international good practices such as international standards given by the International Finance Corporation (IFC)-World Bank (WB) Environmental Health and Safety (EHS) General Guidelines 2007. SPS 2009 also provides that should Government regulations differ from the levels and measures set by the IFC-WB EHS General Guidelines 2007, GDE will achieve whichever is more stringent. The following tables present the environmental standards required to meet national regulations and the IFC-WB EHS General Guidelines 2007. Table 2.2 gives the noise standards, Table 2.3 presents the standards for unpleasant odour, Table 2.4 shows the air quality standards, Table 2.5 gives the effluent limits while Table 2.6 presents the limits for water quality management and pollution control.

Table 2.2: Noise Standards

Receptor	Unit	National Noise Level Limits Ministry of Environment Decree No. 48 of 1996	IFC-WB EHS Guidelines 2007 (Table 1.7.1)	
			Daytime (07:00-22:00)	Nighttime (22:00-07:00)
Residential, institutional, educational	One hour L _{Aeq} (dBA)	55	55	45
Industrial, commercial		70	70	70
Trade and service		70	70 (commercial)	70 (commercial)
Office and trade		65	70 (commercial)	70 (commercial)
Green open space		50	Background level + 3 dB at the nearest receptor location offsite	Background level + 3 dB at the nearest receptor location offsite
Government and public space		60	Background level + 3 dB at the nearest receptor location offsite	Background level + 3 dB at the nearest receptor location offsite
Recreation		70	Background level + 3 dB at the nearest receptor location offsite	Background level + 3 dB at the nearest receptor location offsite
Specific - cultural heritage		60	Background level + 3 dB at the nearest receptor location offsite	Background level + 3 dB at the nearest receptor location offsite
Hospital, school, and religious building		55	55	45
Occupational Health and Safety Limits				
Location/Activity	Unit	Ministry of Manpower Decree No. KEP-51/MEN/1999 regarding Threshold Limit Value of Physical Factors in the Work Environment	IFC-WB EHS Guidelines 2007 (Table 2.3.1)	
		Exposure limit per day	Equivalent level, L _{Aeq} , 8h	Maximum, L _{Amax} , fast
Heavy industry (no demand for oral communication)	dBA	85 (8 hours)	85	110
-	dBA	88 (4 hours)	-	-
-	dBA	91 (2 hours)	-	-
-	dBA	97 (30 minutes)	-	-
Light industry (decreasing demand for communication)	dBA	-	50-65	110
Open offices, control rooms, service counters or similar	dBA	-	45-50	-
Individual offices (no disturbing noise)	dBA	-	40-45	-

Table 2.3: Standards for Unpleasant Odour

Parameter	Unit	Standard	
		KepMenLH No. 50 of 1996	WHO (Europe) Air Quality Guidelines 2 nd Ed. (2000)
Ammonia (NH ₃)	ppm	2.0	-
Methyl Mercaptan (CH ₃ SH)	ppm	0.002	-
Hydrogen Sulphide (H ₂ S)	µg/m ³	28 (24 hours)	7 (30 minutes) odour annoyance
	ppm	0.02 (24 hours)	
Methyl Sulphide ((CH ₃) ₂ S)	ppm	0.01	-
Styrene (C ₆ H ₅ CHCH ₂)	ppm	0.1	-

Table 2.4: Air Quality Standards

Parameter	Averaging Time	Unit	GR No. 41/1999 on Air Pollution Control	MOE Decree No. 50/1996 on Odour Level Standard	MOE Decree No. 15/2019 on Emission Standard of Stationary Emission Source for Thermal Power Generation	Ministry of Manpower Letter No. SE-01/MEN/1997 (Threshold Limit Value of Chemical Factors in the Work Environment)	WHO (Europe) Air Quality Guidelines 2 nd Ed. (2000)	IFC-WB EHS Guidelines 2007
Carbon monoxide (CO)	1 hour	µg/m³	30,000					-
	24 hour	µg/m³	10,000					-
Hydrocarbons (HC)	3 hour	µg/m³	160					-
Nitrogen dioxide (NO ₂)	1 hour	µg/m³	400					200
	24 hour	µg/m³	150					-
	1 year	µg/m³	100					40
Sulfur dioxide (SO ₂)	10 minute	µg/m³	-					500
	1 hour	µg/m³	900					-
	24 hour	µg/m³	365					125 (Interim target 1)
		µg/m³						50 (Interim target 2)
		µg/m³						20
	1 year	µg/m³	60					-
Dust (Total suspended particulates)	24 hour	µg/m³	230					-
	1 year	µg/m³	90					-
Lead (Pb)	24 hour	µg/m³	2					-
	1 year	µg/m³	1					-

Parameter	Averaging Time	Unit	GR No. 41/1999 on Air Pollution Control	MOE Decree No. 50/1996 on Odour Level Standard	MOE Decree No. 15/2019 on Emission Standard of Stationary Emission Source for Thermal Power Generation	Ministry of Manpower Letter No. SE-01/MEN/1997 (Threshold Limit Value of Chemical Factors in the Work Environment)	WHO (Europe) Air Quality Guidelines 2 nd Ed. (2000)	IFC-WB EHS Guidelines 2007
Ozone (O ₃)	1 hour	µg/m ³	50					-
	8 hour daily maximum	µg/m ³	-					160 (Interim target 1)
		µg/m ³	-					100
	1 year	µg/m ³	235					-
Particulate matter (PM ₁₀)	24 hour	µg/m ³	150					150 (Interim target 1)
		µg/m ³						100 (Interim target 2)
		µg/m ³						75 (Interim target 3)
		µg/m ³						50
	1 year	µg/m ³	-					70 (Interim target 1)
		µg/m ³						50 (Interim target 2)
		µg/m ³						30 (Interim target 3)
		µg/m ³						20
Particulate matter (PM _{2.5})	24 hour	µg/m ³	15					75 (Interim target 1)
		µg/m ³						50 (Interim target 2)
		µg/m ³						37.5 (Interim target 3)
		µg/m ³						25
	1 year	µg/m ³	65					35 (Interim target 1)
		µg/m ³						25 (Interim target 2)
		µg/m ³						15 (Interim target 3)
		µg/m ³						10
H ₂ S	-	µg/m ³	-	28	30,000	1,400 (8 hours)	150 (24 hours)	-
NH ₃	-	µg/m ³	-	1,360	400	-	-	-

Table 2.5: Effluent Standards

Parameters	Unit of Measure	Standard ^a
Water temperature	°C	45
pH	-	6 - 9
Hydrogens sulfide	mg/l	1
Ammonia (NH ₃ -N)	mg/l	10
Total mercury	mg/l	0.005
Total arsenic	mg/l	0.5
Oil & Grease	mg/l	15
Total organic carbon	mg/l	110
^a Ministry of Environment Regulation No. 19/2010 on Effluent Standards of Oil & Gas and Geothermal Activities		

Table 2.6: Water Quality Management and Pollution Control Standards

No	Parameter	Unit	Standard ^a
Physical			
1.	Water temperature	°C	Local air temperature $\pm 3^{\circ}\text{C}$
2.	Total dissolved solid	mg/l	1,000
3.	Total suspended Solid	mg/l	50
Chemical			
1.	pH	-	6 - 9
2.	BOD ₅	mg/l	3
3.	COD	mg/l	25
4.	Dissolved oxygen	mg/l	4 (minimum)
5.	Total phosphate	mg/l	0.2
6.	Nitrate (NO ₃)	mg/l	10
7.	Arsenic (As)	mg/l	1
8.	Cobalt (Co)	mg/l	0.2
9.	Boron (B)	mg/l	1
10.	Selenium (Se)	mg/l	0.05
11.	Cadmium (Cd)	mg/l	0.01
12.	Chromium (hexavalent)	mg/l	0.05
13.	Copper (Cu)	mg/l	0.02
14.	Lead (Pb)	mg/l	0.03
15.	Mercury (total)	mg/l	0.002
16.	Zinc (Zn)	mg/l	0.05
17.	Cyanide (CN)	mg/l	0.02
18.	Fluoride	mg/l	1.5
19.	Nitrite (NO ₂)	mg/l	0.06
20.	Free chlorine	mg/l	0.03
21.	Sulfide (as H ₂ S)	mg/l	0.002
22.	Oil and Grease	mg/l	1
23.	Detergent (MBAS)	mg/l	0.2
24.	Phenol	mg/l	0.001

No	Parameter	Unit	Standard ^a
Microbiology			
1.	Fecal coliform	Number/ 100 ml	1,000
2.	Total coliform	Number/ 100 ml	5,000
^a Government Regulation No. 82/2001 on Water Quality Management and Water Pollution Control, Class II - Water Quality Standard for Recreational Purpose, Freshwater Fish Culture, Farming, Vegetation Watering, and Other Purposes Requiring the Same Standard.			

2.1.5 Relevant International Environmental Agreements

99. Aside from the national environmental regulations, international environmental agreements where Indonesia is a party will be referred to in the design and implementation of the project. Table 2.7 lists the applicable international environmental agreements that can provide guidance during project implementation.

Table 2.7: Indonesia Relevant International Environmental Agreements

International Environmental Agreement	Date of Ratification/Accession ^a	Description
Convention Concerning the Protection of the World Cultural and Natural Heritage (Paris 1972)	6 July 1989 (acceptance)	Defines and provides for the conservation of world's heritage by listing the natural and cultural sites whose value should be preserved.
Convention on Biological Diversity (1992)	23 August 1994	A framework for biodiversity and requires signatories to develop national strategies (National Biodiversity Strategy and Action Plan) for the conservation and sustainable use of biological diversity.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington 1973) – also known as CITES	28 December 1978	Entered into force on 28 March 1979. This convention addresses the exploitation patterns and overharvesting that threaten species of flora and fauna. Under this Convention, the governments agree to restrict or regulate trade in species that are threatened by unsustainable patterns and to protect certain endangered species from overexploitation by means of a system of import/export permits.
Vienna Convention for the Protection of the Ozone Layer (adopted in 1985)	26 Jun 1992	Initiatives to protect the ozone layer by means of systematic observations, research and information exchange on the effects of human activities on the ozone layer and to adopt legislative or administrative measures against activities likely to have adverse effects on the ozone layer.
Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol to the Vienna Convention for	26 June 1992	Designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.

International Environmental Agreement	Date of Ratification/Accession ^a	Description
the Protection of the Ozone Layer), 16 September 1987		
Kyoto Protocol (1997)	03 December 2004 30 September 2014 (amendment)	Commits its Parties to set internationally-binding emission reduction targets. This agreement is linked to the UNFCCC. Indonesia signed this agreement on 13 July 1998.
UNFCCC (1992)	23 August 1994	This framework came into force on 21 March 1994 and aims to achieve stabilization of GHG concentrations in the atmosphere at a level low enough to prevent dangerous anthropogenic interference with the climate system.
Paris Agreement (12 December 2015)	31 October 2016	Entered into force on 30 November 2016, this is an agreement within the UNFCCC that deals with greenhouse gas (GHG) emissions mitigation, adaptation and finance beginning 2020.
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989)	20 September 1993	Entered into force on 19 December 1993, this convention aims to reduce the amount of waste produced by signatories and regulate the international traffic in hazardous wastes.
^a Accession – the state accepts the offer or the opportunity to become a party to a treaty already negotiated and signed by other states		

2.2 Environmental requirements of ADB

100. ADB's SPS 2009 provides for the environmental requirements and review procedures of ADB for all projects and grants they finance. SPS 2009 consists of three key safeguard areas, (i) environment, (ii) involuntary resettlement, and (iii) indigenous peoples; aims to avoid adverse project impacts to both the environment and the affected people; to minimize, mitigate and/or compensate for adverse project impacts; and to help Borrowers to strengthen their safeguard systems and to develop their capacity in managing the environmental and social risks.

101. During the project identification stage, ADB uses a categorization system to indicate the significance of potential environmental impacts and is determined by the category of its most environmentally sensitive component, including direct, indirect, cumulative, and induced impacts within the project's area of influence. The project categorization system and the assessment required is described in Table 2.8.

Table 2.8: Environmental Classification based on SPS 2009

Category	Definition	Assessment Requirement
A	Likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented, and may affect an area larger than the sites or facilities subject to physical works.	Environmental impact assessment (EIA)

Category	Definition	Assessment Requirement
B	Likely to have adverse environmental impacts that are less adverse than those of Category A. Impacts are site-specific, few if any of them irreversible, and in most cases mitigation measures can be designed more readily than Category A.	Initial Environmental Examination (IEE)
C	Likely to have minimal or no adverse environmental impacts.	No environmental assessment is required but the environmental implications of the project will be reviewed.
FI	Project involves investment of ADB funds to or through a financial intermediary (FI).	FIs will be required to establish an environmental and social management commensurate with the nature and risks of the FI's likely future portfolio to be maintained as part of the FI's overall management system.

Source: ADB. Safeguard Policy Statement 2009, p. 19. <http://www.adb.org/sites/default/files/institutional-document/32056/safeguard-policy-statement-june2009.pdf>.

2.2.1 Environmental requirements

11. Based on the potential environmental impacts, Dieng Unit 2 is categorized as category B for environment, requiring the preparation of an IEE following the requirements of SPS 2009. This IEE was based on the following documents:

- (i) Dieng AMDAL Addendum 2004;
- (ii) Feasibility Study August 2019;
- (iii) Noise assessment study based on Feasibility Study August 2019;
- (iv) Air quality dispersion modeling based on Feasibility Study August 2019;
- (v) Environmental monitoring reports prepared by a 3rd party (Sucofindo Inc.) submitted regularly to MOEF;
- (vi) Additional baseline environmental quality measurements on noise, ambient air quality, soil, rainwater, and groundwater done in March-August 2019;
- (vii) Quantitative risk assessment of Unit 1 and proposed Unit 2 conducted by an independent consultant in 2019;
- (viii) Safety and environmental audit of Unit 1 done by independent consultant in 2019
- (ix) Critical Habitat Assessment and Biodiversity Action Plan done by independent biodiversity expert in March-July 2019;
- (x) Biodiversity Assessment 2018 by GDE; and
- (xi) Other relevant project documents.

2.2.2 Disclosure requirements

102. Aside from SPS 2009, the Access to Information Policy 2018 (AIP)¹⁴ provides for the requirements of disclosure for project information of projects and grants funded by ADB. Consistent with SPS 2009, AIP 2018 requires the disclosure of documents submitted by the borrower and/or client as follows:

¹⁴ <https://www.adb.org/sites/default/files/institutional-document/450636/access-information-policy.pdf>

- (i) a draft EIA report for category A project, at least 120 days before Board consideration;
- (ii) a draft environmental assessment review framework, where applicable, before appraisal;¹⁵
- (iii) the final EIA or IEE, upon receipt by ADB;
- (iv) a new or updated EIA or IEE, and a corrective action plan, if any, prepared during project implementation, upon receipt by ADB; and,
- (v) the environmental monitoring reports, upon receipt by ADB.

103. To meet the disclosure requirements of ADB, this IEE will be disclosed to ADB website upon submission by GDE. Table 2.9 presents a summary of the implications of SPS 2009 to the project.

Table 2.9: Implications of SPS 2009 to the Project

No.	SPS 2009 Environment Safeguard Principles	Description
1	Use a screening process for each proposed project, as early as possible, to determine the appropriate extent and type of environmental assessment so that appropriate studies are undertaken commensurate with the significance of potential impacts and risks.	A Rapid Environmental Assessment (REA) checklist was completed for Unit 2 and the environment category based on SPS 2009 is B requiring an IEE.
2	Conduct an environmental assessment for each proposed project to identify potential direct, indirect, cumulative, and induced impacts and risks to physical, biological, socioeconomic (including impacts on livelihood through environmental media, health and safety, vulnerable groups, and gender issues), and physical cultural resources in the context of the project's area of influence. Assess potential transboundary and global impacts, including climate change. Use strategic environmental assessment where appropriate.	An IEE following the requirements of SPS 2009 was conducted for Unit 2.
3	Examine alternatives to the project's location, design, technology, and components and their potential environmental and social impacts and document the rationale for selecting the particular alternative proposed. Also consider the no project alternative.	Alternative routes for transmission line and power plant technology options, as appropriate, were considered and included in the IEE.
4	Avoid, and where avoidance is not possible, minimize, mitigate, and/or offset adverse impacts and enhance positive impacts by means of environmental planning and management. Prepare an environmental management plan (EMP) that includes the proposed mitigation measures, environmental monitoring and reporting requirements, related institutional or organizational arrangements, capacity development and training measures, implementation schedule, cost estimates, and performance indicators. Key considerations for EMP preparation include mitigation of potential adverse impacts to the level of no significant harm to third parties, and the polluter pays principle.	An EMP is included in the IEE. The EMP will provide guidance to the construction contractor and their subcontractor (if any) who will be engaged during project implementation to ensure compliance to the relevant provisions in SPS 2009. The EMP will also provide guidance to GDE during operation phase. The EMP includes an environmental monitoring plan (EMoP).

¹⁵ If no further mission for appraisal is required, the document will be posted before the management review meeting or the first staff review meeting for sovereign projects, or before the final investment committee meeting for nonsovereign projects, as applicable (ADB procedures).

No.	SPS 2009 Environment Safeguard Principles	Description
5	Carry out meaningful consultation with affected people and facilitate their informed participation. Ensure women's participation in consultation. Involve stakeholders, including affected people and concerned nongovernment organizations, early in the project preparation process and ensure that their views and concerns are made known to and understood by decision makers and taken into account. Continue consultations with stakeholders throughout project implementation as necessary to address issues related to environmental assessment. Establish a grievance redress mechanism to receive and facilitate resolution of the affected people's concerns and grievances regarding the project's environmental performance.	Two consultation events were conducted on 23-26 March 2019 and on 10-19 September 2019. GDE will conduct regular information, education, and communication initiatives during implementation. A stakeholder communications plan was prepared for Unit 2. A three-tiered grievance redress mechanism, consistent with international best practices is included in the IEE. GDE will ensure the representation of women and community in the grievance redress committee.
6	Disclose a draft environmental assessment (including the EMP) in a timely manner, before project appraisal, in an accessible place and in a form and language(s) understandable to affected people and other stakeholders. Disclose the final environmental assessment, and its updates if any, to affected people and other stakeholders.	Disclosure of the IEE to ADB website will be endorsed by GDE. Any future update to the IEE and EMP will be disclosed.
7	Implement the EMP and monitor its effectiveness. Document monitoring results, including the development and implementation of corrective actions, and disclose monitoring reports.	At the construction phase, the contractor will be responsible for implementing the EMP and will be monitored for compliance by PMU-GDE to be supported by environmental experts, if required. Environmental monitoring reports and corrective action plan (CAP), if needed, will be prepared by PMU-GDE and will be similarly disclosed to ADB website.
8	Do not implement project activities in areas of critical habitats, unless (i) there are no measurable adverse impacts on the critical habitat that could impair its ability to function, (ii) there is no reduction in the population of any recognized endangered or critically endangered species, and (iii) any lesser impacts are mitigated. If a project is located within a legally protected area, implement additional programs to promote and enhance the conservation aims of the protected area. In an area of natural habitats, there must be no significant conversion or degradation, unless (i) alternatives are not available, (ii) the overall benefits from the project substantially outweigh the environmental costs, and (iii) any conversion or degradation is appropriately mitigated. Use a precautionary approach to the use, development, and management of renewable natural resources.	A critical habitat assessment and bird survey were conducted for Unit 2 to determine (if any) the potential project impacts to species such as Javan Hawk-eagle (<i>Nisaetus bartelsi</i>), Silvery Gibbon (<i>Hylobates moloch</i>), etc.
9	Apply pollution prevention and control technologies and practices consistent with international good practices as reflected in internationally recognized standards such as the World Bank Group's Environmental, Health and Safety Guidelines. Adopt	Well development, construction of power plant, transmission line and access road may have impacts that could affect environmental quality. Mitigation measures are included in the

No.	SPS 2009 Environment Safeguard Principles	Description
	cleaner production processes and good energy efficiency practices. Avoid pollution, or, when avoidance is not possible, minimize or control the intensity or load of pollutant emissions and discharges, including direct and indirect greenhouse gases emissions, waste generation, and release of hazardous materials from their production, transportation, handling, and storage. Avoid the use of hazardous materials subject to international bans or phaseouts. Purchase, use, and manage pesticides based on integrated pest management approaches and reduce reliance on synthetic chemical pesticides.	EMP such as enclosures and water spraying to contain dust and noise generation, etc. will be implemented and monitored for compliance. Rock mufflers or silencers will be used to contain noise levels during well drilling, venting and during operation of the power plant. Power station building will be equipped by silencers and lined with noise absorbers and noise barrier walls.
10	Provide workers with safe and healthy working conditions and prevent accidents, injuries, and disease. Establish preventive and emergency preparedness and response measures to avoid, and where avoidance is not possible, to minimize, adverse impacts and risks to the health and safety of local communities.	Construction works may cause accidents or injuries to workers. Contractors will be required to comply with the EMP and workers will be provided with personal protective and safety gears. GDE has a suite of health, safety and environment (HSE) standard operating procedures (see Appendix 7). Compliance of contractors, subcontractor and workers on HSE requirements will be monitored by GDE.
11	Conserve physical cultural resources and avoid destroying or damaging them by using field-based surveys that employ qualified and experienced experts during environmental assessment. Provide for the use of “chance find” procedures that include a pre-approved management and conservation approach for materials that may be discovered during project implementation.	Project sites are not known to have physical cultural resources as defined by SPS 2009. Nonetheless, given that there will be associated excavation works, a “chance find” procedures will be included in the EMP (Appendix 2).

3 Description of the Project

3.1 Brief History of Dieng Geothermal Field

104. The Dieng geothermal field consists of the Sileri sector and the Sikidang sector. The Sileri sector was explored in the early 80s by Pertamina¹⁶ who drilled wells DNG-7, DNG-9 and DNG-10 and discovered a high temperature liquid-dominated reservoir. Sileri sector was then developed in 1995-1998 by Himpurna California Energy (HCE, a wholly owned company of CalEnergy, USA). Sixteen full size geothermal wells were drilled by HCE in Sileri (not including well HCE-10B which was suspended), with a success rate of 14 commercial production wells (87.5%) and total initial production capacity of 184 MW tested at the wellhead. All the HCE production wells, with an average potential of 13 MW, are located in the Sileri sector of the Dieng prospect.

105. Sileri hosts a high temperature (300°C-330°C) liquid-dominated reservoir producing neutral two-phase fluids of low non-condensable gas (NCG) content from depths ranging from 1,500-2,500 m measured depth (MD). The Sikidang sector of the field was attempted to be developed by Pertamina in the 1980s and early 1990s, but had a much lower success rate, lower productivity and high NCG content. For this reason, it was then considered by HCE as a reinjection area for planned Unit 1.

106. Dieng is a liquid dominated geothermal field which hosts relatively deep and high temperature reservoir. Since 2002, the highly productive reservoir in the Sileri area has been providing two-phase fluids with low NCG to Dieng Unit 1 of 60 MWe (gross) installed power plant. The development of 55 MWe (net) Dieng Unit 2 will still be concentrated in the Sileri area which is estimated to extend over an area of at least 7.4 square-kilometers (km²).

3.2 Development and Need for the Project

107. GDE has embarked on Dieng Unit 2 to contribute in meeting the goal of GOI for a 7% share of geothermal in the national energy mix by 2025 as indicated in 2014 NEP. At the same time, the initiative will support the national commitment in COP21 to reduce GHG emissions at 29% by 2030. The implementation of Dieng Unit 2 will also help achieve the national target for 100% electrification by 2020.

108. Dieng expansion project for another 55 MW generation capacity is included in the Fast Track Program which is a flagship program of GOI in electricity infrastructure development. The project is also identified in the National Strategic Program for Electricity Supply Business Plan (*Rencana Umum Penyediaan Tenaga Listrik* or RUPTL) 2019-2028 as needed in order to achieve the target of 7.2 GW geothermal capacity by 2025 as presented in the National General Energy Plan (*Rencana Umum Energi Nasional* or RUEN) of the Ministry of Energy and Mineral Resources (*Kementerian Energi dan Sumberdaya Mineral*).

3.3 Location

109. Dieng Unit 2 is located in the Dieng Plateau area in Central Java which currently has an existing Unit 1 with an installed capacity of 60MW. Unit 2 is about 3 km south-southeast (SSE) of

¹⁶ PT Pertamina (Persero) or Pertamina is the State Oil and Natural Gas Mining Company engaged in oil and gas business activities from the upstream sector to the downstream sector. <https://www.pertamina.com/en/who-we-are>.

the Unit 2 site. The project is within the districts of Wonosobo and Banjarnegara in Central Java (Figure 3.1).



Figure 3.1: Project Location

3.4 Project Components

110. The project will cover development of geothermal production wells, steam above ground gathering system (SAGS), and power plant with an installed capacity of 55 MW. The Feasibility Study Update was completed in August 2019 while front-end engineering design (FEED) and Detailed Engineering Design (DED) will be undertaken during project implementation.

111. The development of Dieng Unit 2 will partly use and upgrade existing access roads, well pads, water supply and supporting infrastructures from the existing Unit 1. An improvement of water supply will be required to support drilling activity. The operation of Dieng Unit 2 will require the following main components:

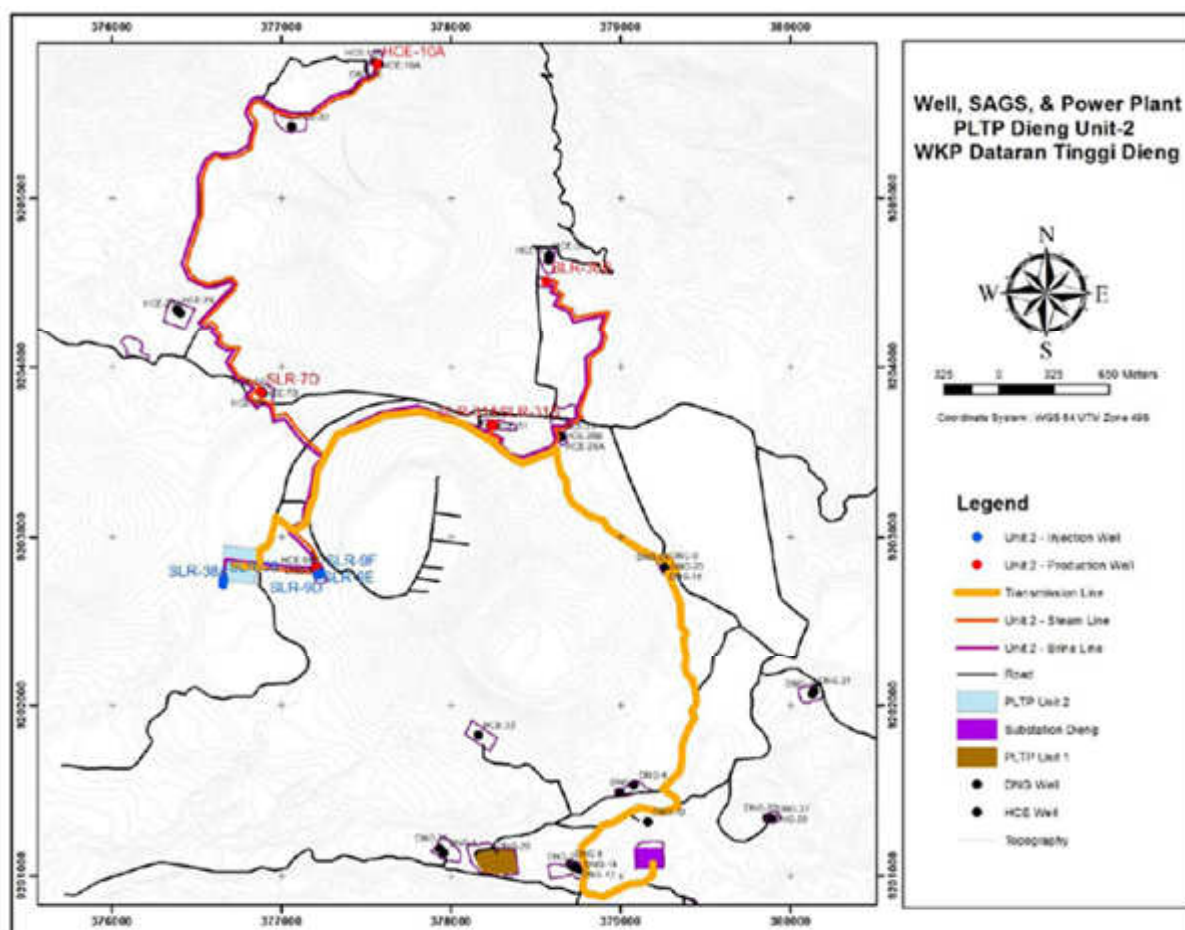
- A total of six production wells of which one well is existing (HCE-10A);
- A total of five new injection wells;
- Power plant with an installed capacity of 1 x 55 MW using a combined cycle power plant technology (i.e., back pressure turbine and organic Rankine cycle bottoming for steam and brine);
- Steam above ground gathering system (SAGS) consisting of about 9.13 kilometer (km) steam pipelines to connect Unit 2 geothermal power plant to the production wells;
- About 5.05 km of injection pipelines to connect Unit 2 to the injection system;
- An underground electric transmission line (150 kV) of about 6.9 km to connect Unit 2 to the existing substation in Unit 1; and
- Access roads of about 1.8 km.

112. The combined cycle power plant can produce more power for the same amount of geothermal fluid production than single flash power plants. A pH modification on the combined cycle power plant will be employed as an effective solution to reduce silica scaling rates and

ensure the increase in the pressure of steam separation. Silica scaling is one of the technical challenges in geothermal power production in Indonesia. Silica can restrict the flow of fluid reducing heat transfer efficiency and is expensive to remove from the equipment. Table 3.1 presents the key project components while Figure 3.2 shows the layout of Unit 2 and its surface facilities.

Table 3.1: Key Project Components of Dieng Unit 2

Component	Description	
Well development and steam above ground gathering system (SAGS)		
Production wells	Well Identification	Location
	SLR-31A	Pad #31 (Loc Q)
	SLR-31B	Pad #31(Loc Q)
	SLR-30B	Pad #30 (Loc O)
	SLR-7D	Pad #7
	SLR-9C	Pad #9
	HCE-10A (existing)	Pad #10
Injection wells	SLR-9D	Pad #9
	SLR-9E	Pad #9
	SLR-9F	Pad #9
	SLR-38	Power Plant (Loc I)
	SLR-38A	Power Plant (Loc I)
Steam pipelines	About 9.13 km from production wells to power plant	
Injection pipelines	About 5.05 km from power plant to injection wells	
Power Plant		
Capacity	Combined cycle GPP: <ul style="list-style-type: none">• Steam turbine (22.5 MW)• Back pressure ORC turbine (12.9 MW)• Brine ORC turbine (25.9 MW) 2 organic fluids (N-butane and iso-pentane)	
Transmission line	About 6.9 km underground cable from Unit 2 to existing substation in Unit 1	
Access road	Pad #7 to Pad I – 1,350 m	
	Pad #9 to power plant – 450 m	
	Upgrade of the public main access road and bridge	



Source: Feasibility Study Dieng and Patuha Expansion, August 2019

Figure 3.2: General Layout of Dieng Unit 2 and Surface Facilities

3.4.1 Well Development

113. A total of six production wells will be required for the operation of Dieng Unit 2 but only five wells will be drilled as one well is already existing (HCE 10-A). Table 3.2 presents the production well plan while Table 3.3 shows the injection well plan. Figure 3.3 shows the location of the wells.

Table 3.2: Production Well Plan for Dieng Unit 2

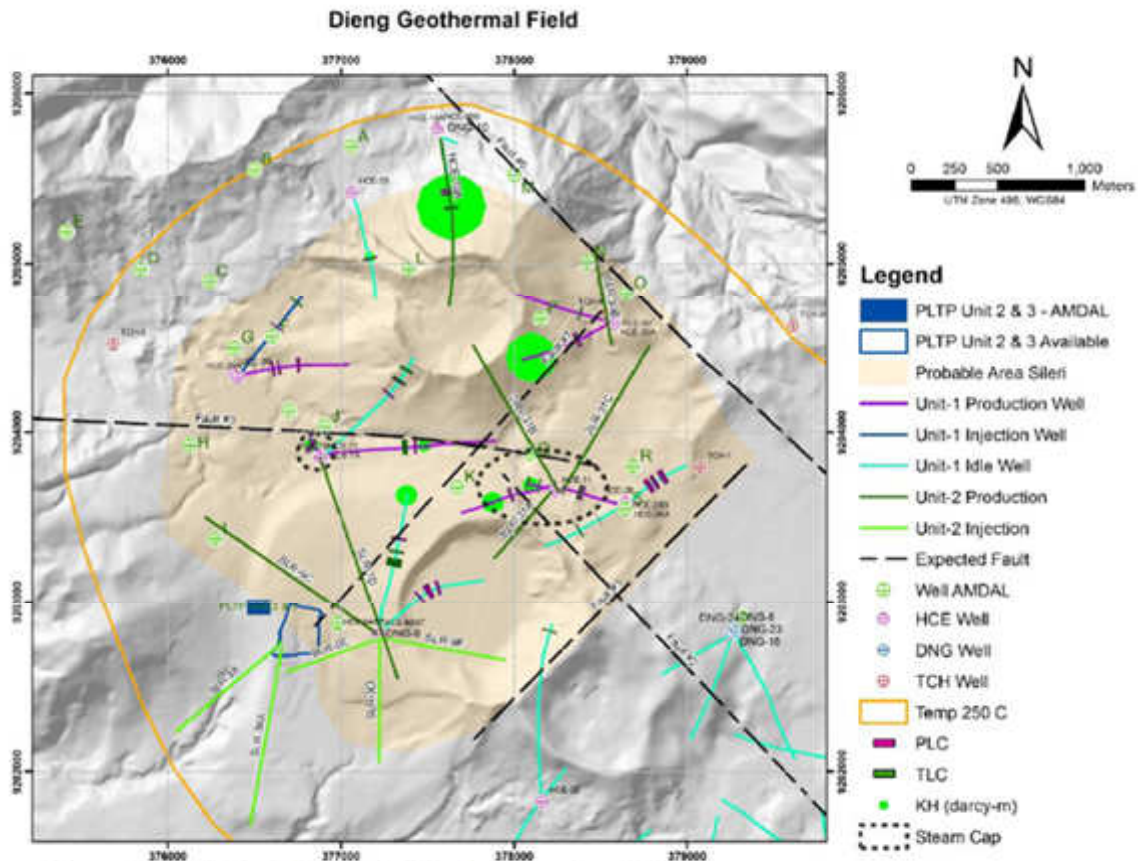
Well	Location	Coordinate		Elevation masl	Incl.	Azimuth NE	KOP		Casing Shoe masl	TD masl
		X	Y				MmD	masl		
SLR-31A	PAD #31	378242	9203653	2083	15	220	800	1284	604	-883
SLR-31B	PAD #31	378256	9203655	2083	40	330	850	1233	557	-845
SLR-30B	PAD #30	378562	9204511	2055	15	350	700	1355	765	-878
SLR-7D	PAD #7	376881	9203844	1919	35	161	400	1519	428	-864
SLR-9C	PAD #9	377202	9202813	2037	40	305	900	1137	667	-836
HCE-10A	PAD #10	377567	9205787	1841	49.5	170	652	1188.62	336	-438

Source: Feasibility Study Dieng and Patuha Expansion, August 2019

Table 3.3: Injection Well Plan for Dieng Unit 2

Well	Location	Coordinate		Elevation	Incl.	Azimuth	KOP		Casing Shoe	TD
		X	Y	masl			MmD	masl	masl	masl
SLR-9D	PAD #9	377223	9202779	2029	20	180	750	1279	236	-845
SLR-9E	PAD #9	377213	9202776	2029	15	250	750	1279	212	-898
SLR-9F	PAD #9	377232	9202782	2029	20	100	750	1279	236	-845
SLR-38	Power Plant	376659	9202748	1995	22	230	750	1245	-5	-851
SLR-38A	Power Plant	376657	9202717	1995	30	190	750	1245	-5	-733

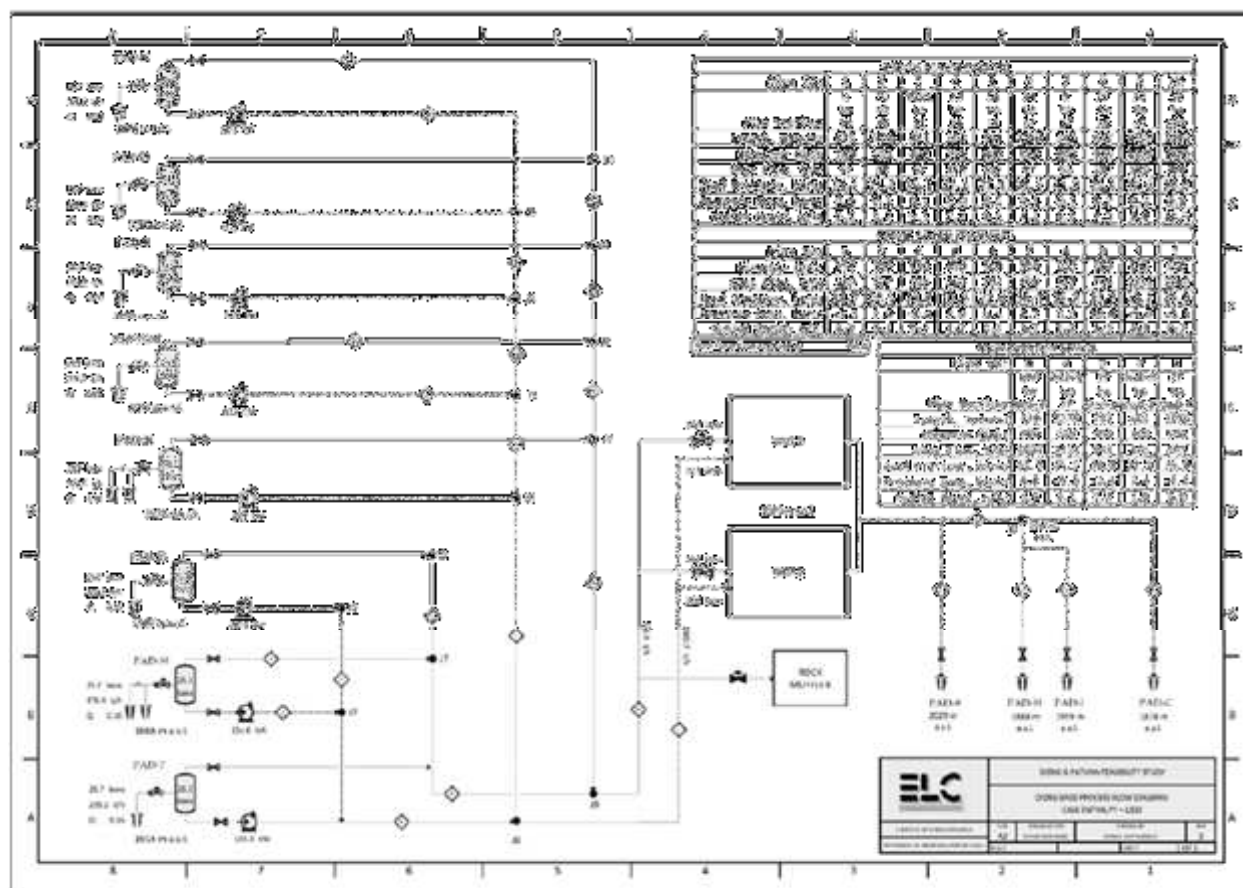
Source: Feasibility Study Dieng and Patuha Expansion, August 2019

**Figure 3.3: Location of the Wells for Dieng Unit 2**

3.4.2 Steam Above Ground System

114. The steam above ground gathering system (SAGS) will consist of the piping and equipment for transporting the geothermal fluid from the wells up to the geothermal power plant and then to the reinjection well pads. SAGS also includes thermal ponds to hold the condensate prior to reinjection and rock mufflers as noise control in case of steam venting. Reinjection is done to maintain the productivity and pressure within the geothermal resource.

115. Pipeline for Dieng Unit 2 will consist of the following which is shown in the process flow diagram of SAGS (Figure 3.4): (i) steam pipelines from well pads to power plant, (ii) brine pipelines from well pads to power plant, and (iii) pipelines from power plant to injection wells.



Source: Feasibility Study Dieng and Patuha Expansion, August 2019

Figure 3.4: Process Flow Diagram of SAGS for Unit 2

Mechanical, electrical, instrumentation and controls

116. Production well pad equipment Each well is equipped with wellhead stop valve, regulation valve, chemical storage, dosing and injection system, control valves, separator, brine pumps and pipes for the connection to the main pipeline. An atmospheric flash tank and a thermal pond is located in each pad, for collecting all flashed fluids during start up, well testing activity or emergency discharge. Cold brine would be pumped into condensate, brine and two-phase lines in that order of preference at a slow rate to mix with the fluid and reinjected. A 6.3 kV distribution line will start from the power plant and reach all pads, to feed the brine pumps through a MV electric panel and a MV/LV transformer

117. Pressure Control Wellhead pressure will be controlled at each well by the flow control valve to minimize silica scaling. Small pressure variations in the main steam delivery system will be controlled by the steam turbine governor valve. High fluctuations in pressure will be compensated by the venting system which discharges the excess steam to a rock muffler.

Several lines will be used to discharge the excess steam into the rock muffler during plant start up, shut down or trip. Zero discharge from the vent station can be achieved if the flow from the wells is steady, otherwise a small amount of steam may continue to vent from the rock muffler during operation. The vent station will be located within the power plant to allow for more stable operation of the SAGS and an easier turbine start-up.

118. Monitoring equipment This is provided to permit the control of the SAGS process and avoid working in a pressure-temperature condition favorable for the silica scaling. Monitoring items will include: (i) Production well pad (production wellhead pressure, production well outlet pressure/temperature/flow volume, production well pad outlet pressure/temperature/flow volume, and brine pump status; and Power Plant drain reinjection pipeline (drain temperature, reinjection well inlet pressure/temperature/flow volume).

119. Data transmission local panels will be installed at production well pads, separator station, reinjection area, emergency pond, etc., where data can be transmitted from local panels through optical fiber cable. Optical fiber cables will be wired along steam pipelines and protected by cable tray. The local panels will be made of steel painted with anti-corrosion paint.

120. Brine handling system and silica scale mitigation A pump sucks brine below the separator and sends it to the dosing device and to the wellhead. Sulfuric acid (H_2SO_4) will be diluted to about 0.5% before injection. The injection point will be between the stop valve and control valve, into a high-alloy static mixer. The mixer and piping designs will have to be optimized for each well once the well production rates are known. A sump with acid-resistant coating will be made around the acid tank, to collect the acid in case of failure or accident. Specific safety procedures will be prepared for the transportation, storage and handling of sulfuric acid in each pad. GDE has standard operating procedures on health, safety, and environment (HSE SOP) on chemical handling (SOP-025-R1) and SOP-037-R1 [Management of hazardous and toxic wastes ("B3 wastes")].

121. Condensate injection system Reinjection will be from Pad 9 and Pad I for Unit 2 and condensate will be mixed with brine for reinjection. If there is any sign of corrosion or scaling issues, the condensate may be reinjected in one of the reinjection wells in Pad 9, only 400 m far from the power plant area. Brine will be directly sent to the reinjection system without passing through a pond. This will keep sufficient pressure such that reinjection pumps will not be required but will have a valve to assure the correct brine pressure in the SAGS and inside the power plant.

122. Steam flow line Pipelines are designed to obtain a steam velocity in the range 20 m/s (mps) to 30 mps. The detailed design of the pipeline will be finalized after the actual well output curves are determined. Loops will be installed along straight trenches, at a distance of about 150m to 200 m to allow thermal expansion. Loops may be horizontal or vertical. Horizontal loops will be used for steam and saturated liquid lines if there are no space constraints as they do not represent a slope interruption. Vertical loops will be used when the available space is limited, to cross roads or to avoid severance (i.e. access to fields and property). Liquid traps will be located in all low points of the pipelines. Condensate or brines, normally in small quantities in the steam pipelines, may be discharged locally in small pits.

123. Civil works Civil works will include construction of one new well pad (Loc-I, where injection wells will be located) and access roads (i.e. from Pad #7 to Pad I – 1,350 m; from Pad #9 to power plant – 450 m; and upgrades to the public main access road and bridge). The new well pad will require an operational area of about 150 m x 120 m. The pavement construction will be sufficient for occasional heavy traffic during steam field development and then lighter

maintenance vehicles thereafter, on a subgrade of weathered volcanic ash, or similar strength in-situ materials. Minor repair and improvement works will be required at existing well pads that where new wells will be drilled. These include (i) rehabilitation of brine ponds at well pads 10 and 30; (ii) silica collection and storage at well pads 7 and 30; and (iii) access control to existing wells pads 7, 9, 30 and 31 including fencing gate and security guard.¹⁷

3.4.3 Power Generation System

124. The power generation system will be a single flash system combined cycle power plant: The two-phase geothermal fluid (i.e. brine and steam) passes through a separator; the separated brine is routed to heat exchangers while the separated steam is routed to the primary back pressure turbine. The exhaust from the back pressure turbine is routed to a heat exchanger together with the separated brine where heat is further extracted in the heat exchanger by organic fluid (i.e., butane and iso-pentane). The organic fluid is then expanded at organic turbine producing additional power. Both primary and secondary turbines drive its own generator to produce electrical energy. The cooling system for the power plant will use air as coolant. The process flow diagram of the power generation system is shown in Figure 3.5 while Table 3.4 presents the overview of power plant.

Table 3.4: Power Plant Overview of Dieng Unit 2

Parameter		
Power Plant	Location	Located in acquired land by GDE
	Type	Combined cycle consisting of: (i) steam turbine; (ii) ORC bottoming turbine; and (iii) ORC brine
	Power Output (net)	Steam turbine – 22.5 MW, Back-pressure ORC turbine – 12.9 MW, and brine ORC turbine – 25.9 MW 55 MW
	Power Output (gross)	58 kW
	Turbine Inlet Pressure	Steam turbine – 19 bar _a ORC bottoming turbine – 1.2 bar _a ORC brine – 23.2 bar _a
	Turbine type	One flow type, speed 3000 rpm
	NCG Content	Approx. 1% wt
	NCG Extraction System	1 st stage steam ejector, vacuum pump, 2 nd stage steam ejector as back up
	Secondary fluid for binary	ORC bottoming turbine – butane Inlet pressure – 18.8 bar _a and at temperature of 94.7°C Outlet – 3.77 bar _a and at temperature of 40°C Flowrate – 1,001.8 tons/hr ORC brine – iso-pentane Inlet – 15 bar _a and a temperature of 146.2°C Outlet – 1.15 bar _a and at temperature of 40°C Flowrate – 1,052.3 tons/hr
	Other main equipment	Steam turbine – demister ORC bottoming turbine and ORC brine – air-cooled, mechanical draft, multi-cell condenser, heat exchanger, extraction pumps
Transmission	Dispatch voltage	150 kV

¹⁷ These repair works are recommendations of the independent safety audit, as described in Appendix 6 and 7.

Parameter		
	Length	6.9 km
	Connection line	150 kV
	Tower	Underground cable
	Substation	Existing Dieng substation

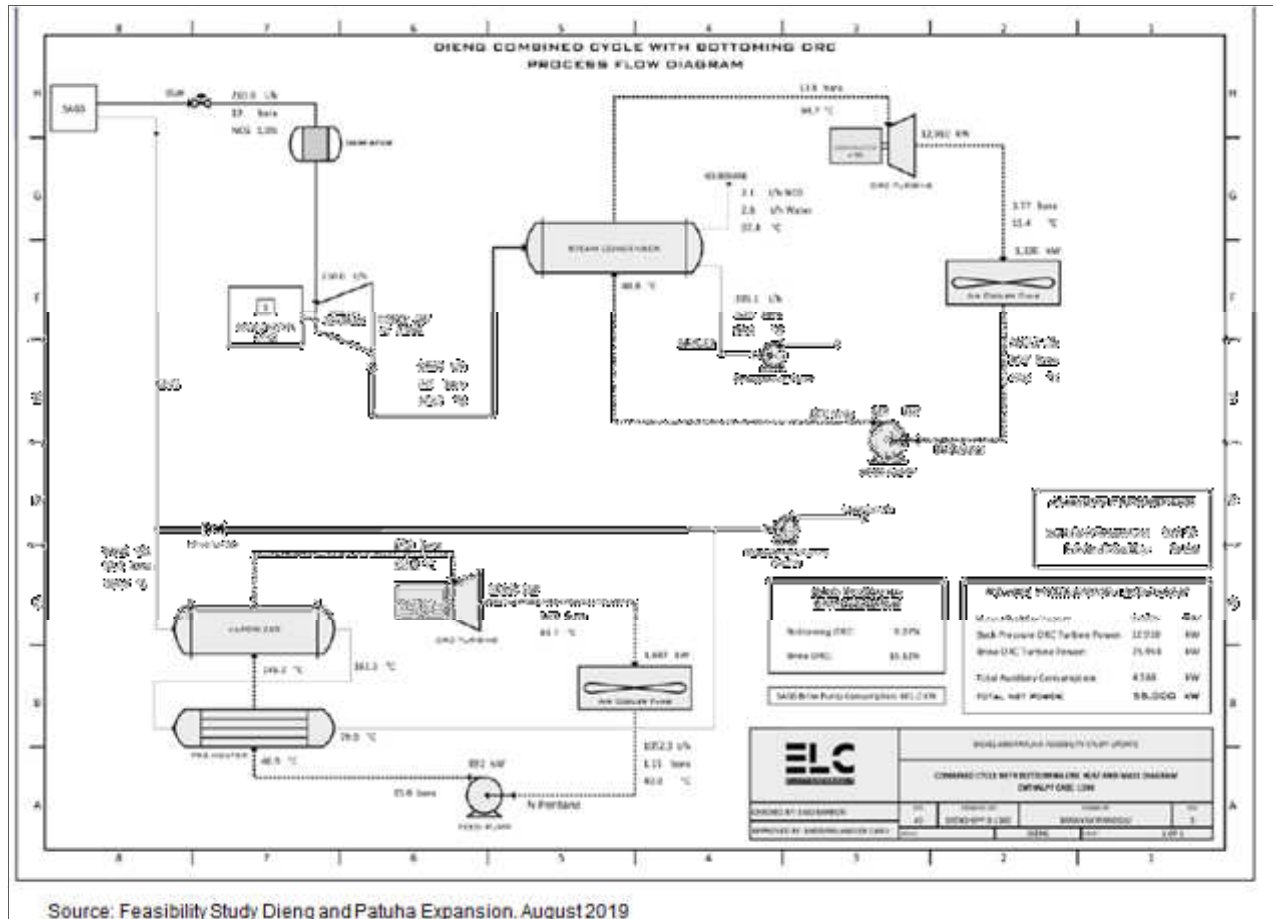


Figure 3.5: Process Flow Diagram of Power Generation System for Unit 2

3.5 Project Activities

3.5.1 Pre-construction Phase

Front end engineering design/Detailed engineering design

125. This phase will confirm the specifications and requirements where one of the basis is the Feasibility Study Update August 2019. The activities aim to develop an approved for construction design including tender documents and this include the following:

- Detailed site investigation - Conduct detailed site investigation including flood risk assessment, storm drainage analysis.

- Seismic considerations in plant design - Conduct seismic hazard study and demonstrate that power plant structural design is seismically safe for anticipated seismic risks. The structural design is to be checked by a suitably qualified and experienced third-party structural engineer who is independent of GDE, their designer and contractor.
- Communication, Grievance redress mechanism (GRM) -Establish GRM, establish information center, interactive 3-D models, video etc, produce leaflets, etc on project aspects (FAQ, IEE/EMP, GRM), establish and maintain project website and/or social media presence,
- Consideration of operation phase impacts in the DED - Conduct detailed air dispersion modeling based on DED, confirming compliance with ambient H₂S level (28µg/m³, 24-hr averaging time) and emission level (30 mg/Nm³); conduct detailed noise modeling based on DED, demonstrating compliance with IFC guideline values (55dB/45dB or 3dB increment); disseminate results to potentially affected people.
- Integration of aesthetic elements in design - incorporate landscape architecture elements into the detailed project design to optimize harmonious integration of the infrastructure into the landscape.
- Storage and handling of butane and iso-pentane – conduct explosion risk assessment; demonstrate compliance with the most stringent international industry codes and standards.
- Land acquisition for the new well pad (Loc I) about 18,000 m², pipeline and access road from Pad 7 to Pad I about 13,500 m², and from Pad 9 to Unit 2 about 4,500 m²

Demolition of Existing Structures at the Project Site

126. Several existing but abandoned structures at the site of Unit 2 powerplant will need to be demolished. Activities will include: (i) rapid assessment survey and study to determine presence of asbestos-containing materials (ACMs); (ii) prepare demolition plan based on the rapid assessment; (iii) review and approval of demolition plan by PMU and relevant government agency (e.g., MOEF at district level); (iii) demolition works.

3.5.2 Construction Phase

127. Activities during this phase include land acquisition, preparation of well drilling plan and schedule, workforce recruitment, land clearing and preparation, selection of basic engineering equipment and support facilities, determine route and frequency of transportation from source of materials to the well drilling site, equipment and material mobilization, and access road construction or improvement; identification of sources of construction materials and supplies; recruitment of workforce; transport and mobilization of heavy equipment and machineries; earthworks; civil, mechanical, and electrical works; delivery of main equipment for power plant such as steam turbine, generators, condensers, cooling towers, etc.; reliability testing for provisional acceptance certificate, environmental compliance monitoring of construction activities, and overall project management.

128. After drilling is completed, each well will be subject to testing to determine if it will be useful for power generation. Main activities include: preparation of well testing plan and schedule, identify safety measures during well testing, recruitment of workforce, selection of basic engineering equipment and support services, determine volume of waste that will be generated during well testing and management, evaluate/determine well chemistry, and well closure.

3.5.3 Operation Phase

129. Prior to commissioning of SAGS, Unit 2 and its support facilities, quality assurance/quality control tests and inspections will be undertaken. Other main activities are: recruitment of workforce with required qualifications, commissioning and connection of Unit 2 to the national grid, environmental monitoring for compliance to the requirements of GOI and ADB; and appropriate O&M to ensure the reliable power generation throughout its economic life; develop/update the HSE SOPs and other relevant protocols; and Implement HSE measures and secure international accreditation to ISO and OSHAS.

3.5.4 Decommissioning Phase

130. Decommissioning can be during well development or after the end of the economic life of Unit 2. Should there be a need for decommissioning during well development, some of the activities will include:

- sump that was used will be backfilled with previously stripped topsoil which is kept reserved;
- revegetation will be done after backfilling;
- well pad will be capped, secured, and maintained for monitoring purposes; and
- reusable items and equipment will be stored and used with other similar projects.

131. If decommissioning will be at the end of the economic life expected to be 30 years, a decommissioning plan will be prepared following the EHS requirements of Indonesia and ADB. Consultations will be conducted to the villages in Karang Tengah, Dieng Kulon, Bakal, Kepakisan, Pranten and Sikunang will be conducted during the preparation of the decommissioning plan to ensure that the same will be appropriate to the local land use plan. The decommissioning plan will cover measures to restore the site to as close as practicable to its pre-development condition and will depend on the intended use of the area and the reusability of existing facilities to other GDE facilities by that time.

3.6 Overall Project Implementation Arrangements and Schedule

132. The project is expected to be implemented from 2020-2024. GDE will be the EA responsible for the overall supervision and management of project implementation. A PMU will be set up by GDE for the overall day-to-day management and supervision of project activities in coordination with the project management consultant (PMC). The PMC will be engaged to provide technical support to the PMU in carrying out their project management functions. The PMU will ensure compliance to the environmental requirements of SPS 2009. Environmental safeguard staff will be recruited in the PMU and the PMU to provide environmental technical support to PMU on compliance to SPS 2009. Detailed institutional arrangements and responsibilities are presented in the environmental management plan (EMP). Figure 3.6 shows the overall implementation plan.

3.6.1 Overall Project Implementation Plan

Indicative Activities	2019		2020				2021				2022				2023				2024			
	Quarter		Quarter				Quarter				Quarter				Quarter				Quarter			
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Establishment of project management unit																						
Advance contracting actions for goods, civil works, consulting services and drilling related works and services.																						
Project outputs																						
Output 1: Geothermal power plants constructed and commissioned.																						
1.1 Issue bidding documents for Patuha EPC contract.																						
1.2 Issue bidding documents for Dieng EPC contract.																						
1.3 Commission Patuha 2.																						
1.4 Commission Dieng 2.																						
Output 2: Institutional capacity of GDE strengthened.																						
2.1 Training for GDE corporate and plant staff on reservoir management.																						
2.2 GDE participation in procurement and contract management program.																						
2.3 Environmental management system updated.																						
Output 3: Partnership and community development program improved.																						
3.1 GDE corporate and community communication strategy developed.																						
3.2 Community consultations on strategic development program activities conducted.																						
3.3 Feasibility study on direct use of geothermal prepared incorporating community feedback.																						
Project monitoring and reporting																						
(i) Environment management plan key activities																						
(ii) Gender action plan key activities																						
(iii) Communication strategy key activities																						
(iv) Periodic project review																						
(v) Midterm review																						
(vi) Project closing activities																						

4 Description of the Environment (Baseline Data)

4.1 Project Area of Influence

133. The project area of influence (PAI) considered in this IEE covers the site where Unit 2 will be located, the production wells and injection wells, the transmission line to support its operation, and the existing substation near Unit 1 to evacuate the power that will be generated by Unit 2. These areas are within the jurisdiction of six villages given below:

Province	District	Subdistrict	Village
West Java	Wonosobo	Batur	Bakal
			Karang Tengah
			Kepakisan
			Dieng Kulon
	Banjarnegara	Kejajar	Sikunang
	Batang	Bawang	Pranteen

134. The PAI is within the Dieng Plateau with limited forest area as it has been extensively used mainly for agriculture – primarily potatoes, cabbage, carrots, pepper, Carica Dieng (*Carica candamarcensis* sp.) and other cash crops. Figure 4.1 shows the PAI.

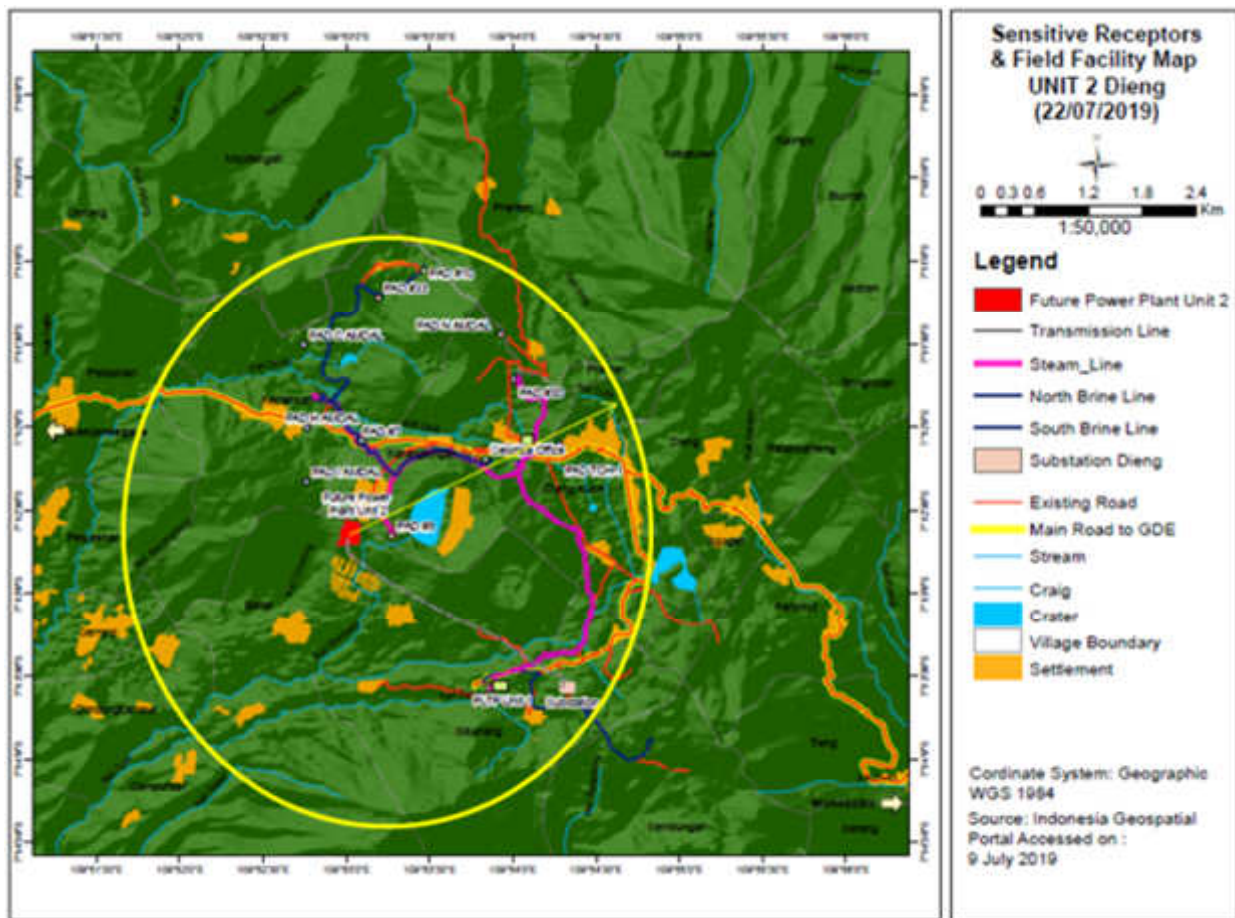


Figure 4.1: Project Area of Influence

4.1.1 The Dieng Unit 1

104. Dieng Unit 1 including its associated production and injection wells, supporting facility and infrastructures are also located in Dieng Plateau area and within the districts of Wonosobo and Banjarnegara in Central Java Province. The nearest The GDE's Dieng Unit 1 geothermal power operations including its associated producing and injection wells, supporting facility and infrastructure are located within Dieng Plateau area, and two administrative areas, i.e, Wonosobo District and Banjarnegara District, Central Java Province. The nearest town from the GDE Dieng operation is Wonosobo, the capital of Wonosobo District, approximately 30 km south of Dieng. Table 4.2 presents the administrative location of Unit 1 and its supporting geothermal wells while Figure 4.2 shows the power plant lay-out.

Table 4.2 Administrative Location of Unit 1 and Wellpads

Power Plant and Well Pad	Administrative Area		
	Village	Subdistrict	District
Dieng unit 1 power plant	Sikunang	Kejajar,	Wonosobo
Well pad #7	Kepakisan,	Batur	Banjarnegara
Well pad #28	Karang Tengah	Batur	Banjarnegara
Well pad #29	Kepakisan	Batur	Banjarnegara
Well pad #30	Karang Tengah	Batur	Banjarnegara
Well pad #31	Karang Tengah	Batur	Banjarnegara

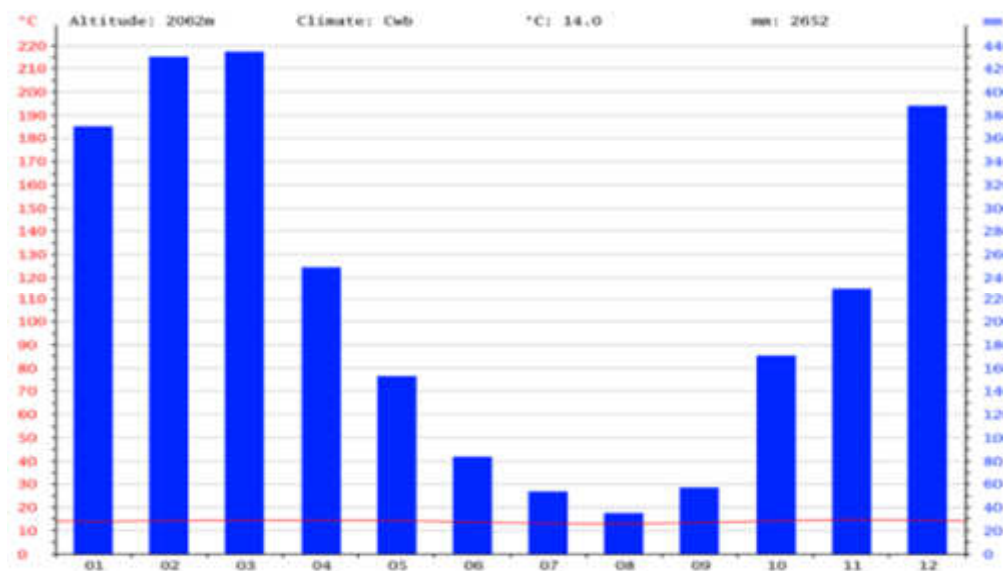


Figure 4.2: Plant Lay-oy of Dieng Unit 1

4.2 Physical Environment

4.2.1 Climate and Meteorology

135. **Overview and Seasonal Pattern.** The Dieng Plateau has elevation of up to 2,060-m above mean sea level, and therefore has a distinct subtropical highland climate type of 'Cwb' according to the classification of Köppen and Geiger. In its brief dry season, which is meteorologically aligned with the Southern Hemispherical winter season, the rainfall rate is less than in its lengthy monsoon (wet) periods in line the austral summer. The rainy season typically occurs from October to May. The main variable of Indonesia's climate is typically rainfall rate significantly influenced by elevation of an area and monsoon patterns. Figure 4.2 presents the variation of rainfall rates (marked in blue bar chart and axis) and an average temperature of around 14 °C (marked in red line and axis) at Dieng Plateau, in which the planned development of Dieng Unit 2 is located, over 12-months period in 2018. The total rainfall rate in Dieng Plateau reached approximately 2700 mm per annum.



Source: <https://en.climate-data.org/asia/indonesia/dieng/dieng-623617/#climate-graph> (accessed on 16 Sep 2019)

Figure 4.2: Rainfall Rate in Dieng Plateau 2008 - 2012

136. Since Indonesia's islands are surrounded by sea, the climate is characterized as marine equatorial with light winds and frequent thunderstorms. There are two major seasons in Indonesia i.e., the dry season and the rainy monsoon season. The wet season for most of Indonesia is typically around September to March and the dry season around April to September, but due to global climate change effect, the timeline for these seasons have shifted. Further, the times of these seasons vary from one place to another due to difference in the effect of monsoon wind patterns across the Indonesia archipelago.

137. **Temperature and Humidity.** The average annual temperature in Dieng is 14°C. Table 4.1 presents the weather data recorded in 2018 indicating that the lowest and highest temperature ranging between 7.6 °C in August to 19.2 °C in November, and humidity between 73% and 88%., Ground frosts have been occasionally recorded every year, particularly in late evenings and

mornings of July and August. This situation may last for one week in average, and it is called as 'Bun Upas' by local people.

Table 4.1: Average Monthly Temperature and Humidity in 2018

Month	Monthly Temperature (°C)			Humidity* (%)
	Average	High	Low	
January	13.9	17.9	10.0	75
February	14.3	18.5	10.1	79
March	14.4	18.6	10.3	77
April	14.4	18.4	10.4	81
May	14.3	18.5	10.1	77
June	13.8	18.5	9.2	78
July	13.2	18.2	8.3	78
August	12.8	18	7.6	74
September	13.8	18.5	8.7	73
October	14.2	18.8	9.6	80
November	14.7	19.2	10.3	87
December	14.4	18.8	10.1	88

Sources:

Temperature: <https://en.climate-data.org/asia/indonesia/dieng/dieng-623617/#climate-graph> (accessed 16 Sep 2019).

Humidity: <https://www.worldweatheronline.com/dieng-weather-averages/central-java/id.aspx> (accessed 16 Sep 2019).

138. **Rainfall.** The pattern of rainfall varies from one island to another, and also within islands as they are affected by the presence of mountains, prevailing winds, and monsoons. The dry season is influenced by the air mass from Australian continent, and the rainy season is by that from mainland Asia and the Pacific Ocean. The rainfall rate of below 100 mm (considered a dry season) was recorded for May up to October. The lowest rainfall rate of below 40 mm was recorded in August and the highest one of more than 420 mm was in March (Figure 4.3).

139. The rainfall intensity described earlier appears to generally correspond with the number of rainy days (Table 4.2), whereby the low rainfall rate occurred in May – October was also recorded with a trend of relatively low number of rainy days for this period. On the other hand, the high rainfall rate corresponds with relatively high number of rainy days for November to April period.

Table 4.2: Number of Rainy Days in 2018

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of rainy days	28	29	24	27	17	12	4	1	15	31	30	31

Source: <https://www.worldweatheronline.com/dieng-weather-averages/central-java/id.aspx>

140. **Wind Speed.** Prevailing wind patterns interact with local topographic conditions to produce variations of wind speed throughout the Indonesian archipelago. The average maximum wind speed was recorded almost 9 km/h (in October) and the minimum one was almost 3 km/h (in April) as shown in Table 4.3.

Table 4.3: Wind Speed Recorded in 201

Month	Average Wind Speed (km/h)	
	Max	Min
January	6.4	4.8
February	5.9	4.4
March	4.3	3.2
April	4.4	3.2
May	4.2	3.3
June	4.7	3.7
July	4.9	3.9
August	5.0	4.1
September	5.5	4.4
October	8.6	5.2
November	7.5	4.4
December	7.3	4.6

4.2.2 Ambient Air Quality and Noise

141. **Ambient Air Quality.** GDE Dieng has an obligation under the requirements of addendum ANDAL and RKL-RPL (2004) to conduct semi-annual monitoring of ambient air quality within its operational areas and report this result to related government agencies at local and national levels. This monitoring is undertaken at several locations representing the sensitive receptors (i.e., the settlement areas of the villages/sub-villages in Bakal, Praten, Ngandam, Pawuhan, Karangsari, Karang Tengah, Kepakistan, Simpangan, Sikunang, and Dieng Kulon) and two locations representing the existing Dieng Unit 1 power plant and office area). Figure 4.3 shows the location of the mentioned monitoring stations.

142. Table 4.4 presents the semi-annual monitoring results of ambient air quality conducted by GDE's contractor in 2018 and interpret them against the prevailing regulations stipulated by the Indonesian Government. The results indicated that the concentrations of sulfur dioxide, nitrogen dioxide, oxidant, hydrocarbons, carbon monoxide, dust (total suspended particulates), and lead were well below the respective threshold values of the ambient air quality standard¹⁸. Nevertheless, relatively high dust concentrations of more than 120 µg/Nm³ (against the threshold value of 230 µg/Nm³) were measured at Ngandam, Pawuhan, Karangsari, Simpangan, and Sikunang. This situation may be attributable to high traffic conditions, unpaved road or dry season period. On the other hand, the concentrations of ammonia and hydrogen sulfide were well below the respective threshold values of the odor standard¹⁹ that may be attributable to good dispersion or low amount of hydrogen sulfide releases.

143. Additional ambient air quality sampling for Bakal and Pranten Villages were commissioned as part of this IEE in April 2019. The samples were collected near the village hall of those two villages analyzed for part of the ambient air quality and odor parameters. In particular, the concentrations of particulate matter <10 µm (PM₁₀) and <2.5 µm (PM_{2.5}) in the ambient air quality were also analyzed. The analytical result of these samples is shown in Table 4.5), suggesting

¹⁸ Government Regulation No. 41/1999 on Air Pollution Control.

¹⁹ Ministry of Environment Decree No. 50/1996 on Odor Standard.

that: (i) baseline concentration of hydrogen sulfide at Bakal village, within the proximity of Karang Tengah village where the Dieng Unit 2 power plant will be located, was measured at 0.040 ppm, which is double than the threshold value of 0.02 ppm set by the Indonesian Odor Standard; and (ii) similarly, the concentration of hydrogen sulfide at Pranten village, a way downhill of well pad #30, was measured at 0.037 ppm, which is almost double than set threshold value mentioned earlier. Figure 4.4 shows the ambient air quality sampling stations at Pranten and Bakal Villages.

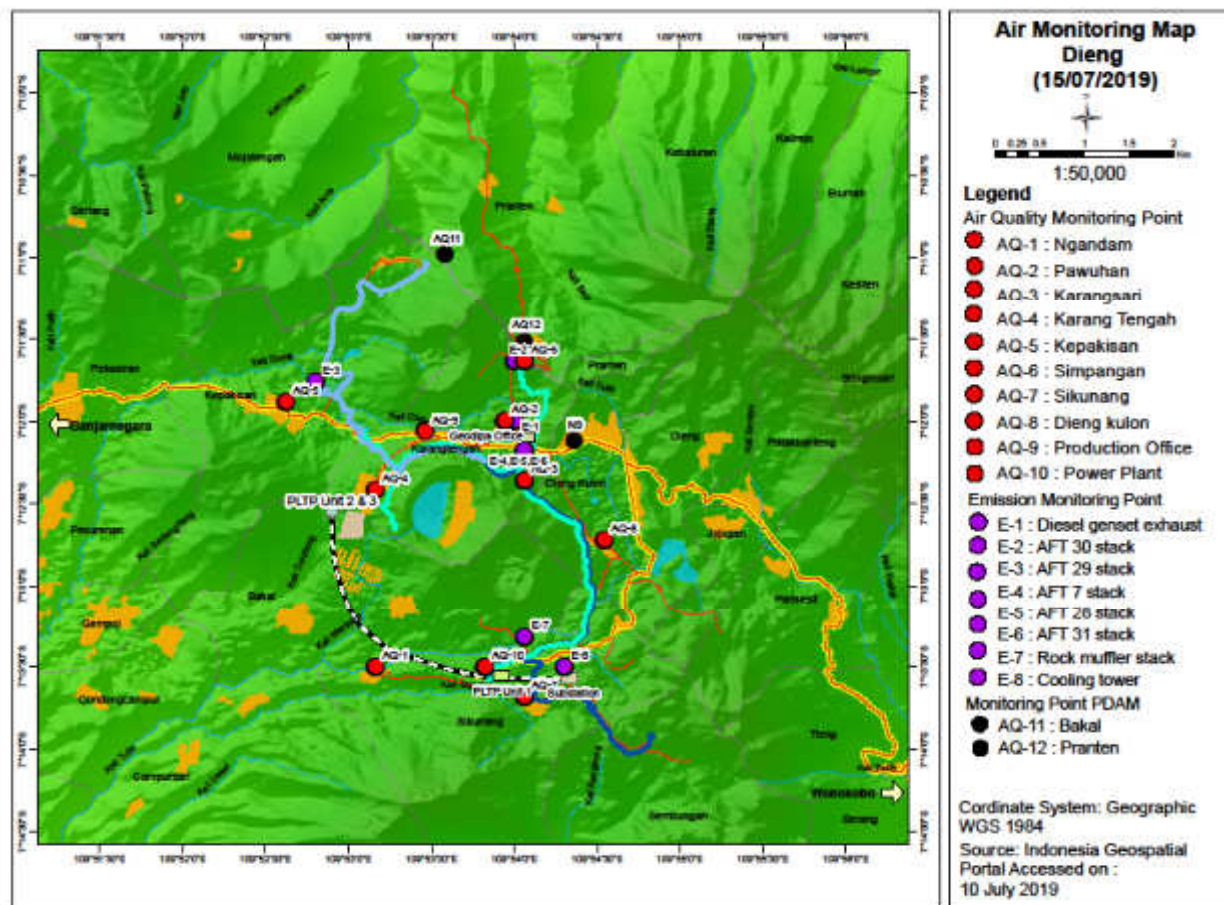


Figure 4.3: Regular Air Quality Monitoring Stations



Near the village hall at Pranten



Near the village hall at Bakal

Figure 4.4: Air Quality Monitoring Stations

Table 4.4: Ambient Air Quality Monitoring Results of 1st Semester/2018

Parameter	Gol Threshold	AQ-1	AQ-2	AQ-3	AQ-4	AQ-5	AQ-6	AQ-7	AQ-8	AQ-9	AQ-10
Sulfur Dioxide (SO ₂)	365 µg/Nm ³	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63
Nitrogen Dioxide (NO ₂)	150 µg/Nm ³	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71
Oxidant (O ₃)	200 µg/Nm ³	7.56	< 2.96	14.82	4.81	< 2.96	4.21	< 2.96	6.49	5.82	5.10
Hydrocarbon	160 µg/Nm ³	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Carbon Monoxide (CO)	15,000 µg/Nm ³	< 11	126	103	11	57	92	137	149	< 11	< 11
Dust (total suspended particulates)	230 µg/Nm ³	179.1	109.7	135.0	72.1	43.3	141.9	173.2	107.9	47.6	40.2
Lead (Pb)	2 µg/Nm ³	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ammonia (NH ₃)	2 ppm	0.029	0.037	0.010	0.106	0.031	0.022	0.004	0.008	0.024	0.019
Hydrogen Sulfide (H ₂ S)	0.02 ppm	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.002

Table 4.5: Ambient Air Quality Monitoring Results of 2nd Semester/2018

Parameter	Gol Threshold ^{1,2}	AQ-1	AQ-2	AQ-3	AQ-4	AQ-5	AQ-6	AQ-7	AQ-8	AQ-9	AQ-10
Sulfur Dioxide (SO ₂)	365 µg/Nm ³	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63	< 39.63
Nitrogen Dioxide (NO ₂)	150 µg/Nm ³	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71	< 23.71
Oxidant (O ₃)	235 µg/Nm ³	15.6	21.73	16.98	10.67	4.48	28.51	7.84	6.59	8.46	18.5
Hydrocarbon	160 µg/Nm ³	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Carbon Monoxide (CO)	15,000 µg/Nm ³	34	115	69	34	103	206	137	252	69	57
Dust (total suspended particulates)	230 µg/Nm ³	92.6	220	51.1	73.4	58	94.4	48	94	82.6	79.2
Lead (Pb)	2 µg/Nm ³	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ammonia (NH ₃)	2 ppm	0.044	0.002	0.011	0.003	0.087	0.034	0.002	0.016	0.068	0.075
Hydrogen Sulfide (H ₂ S)	0.02 ppm	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	0.0003	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Source: RKL-RPL implementation reports (GDE Dieng, 2018).

Note:

AQ-1: Ngadam

AQ-2: Pawuhan

AQ-3: Karangsari

AQ-4 Karang Tengah

AQ-5: Kepakisan

AQ-6: Simpangan

AQ-7: Sikunang

AQ-8: Dieng Kulon

AQ-9: GDE Production office

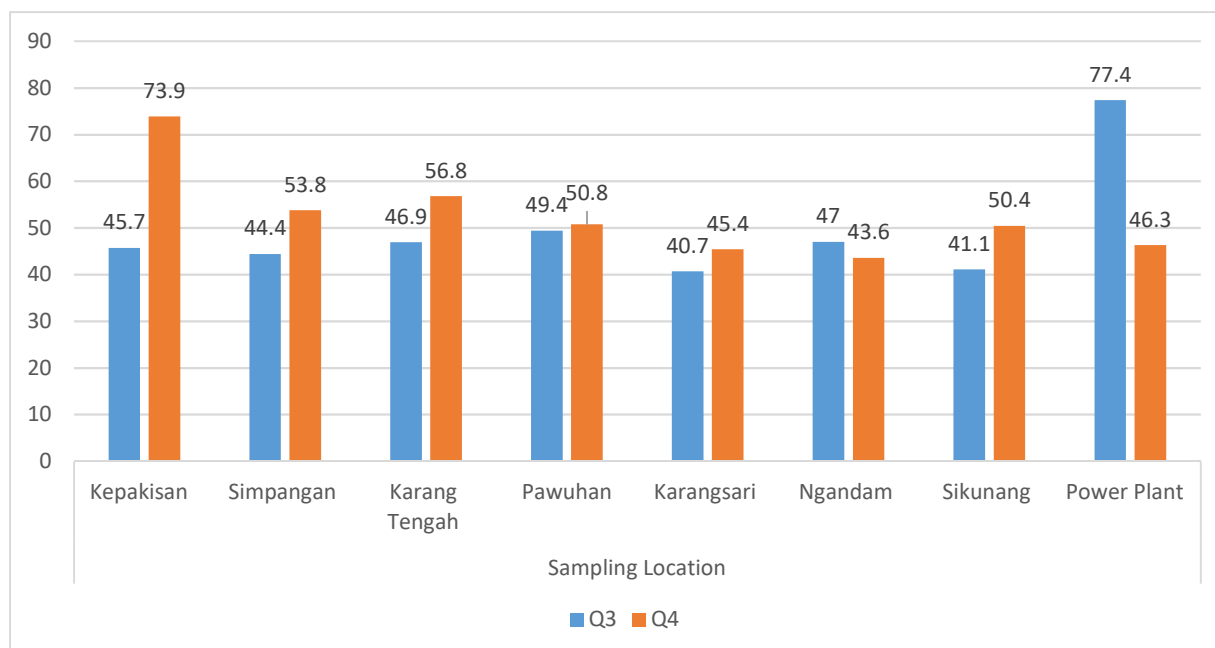
AQ-10: Power plant

Table 4.6: Additional Air Quality Sampling Results (April 2019)

Parameter	Gol Threshold	Bakal Village	Pranten Village
Nitrogen Dioxide (NO ₂)	150 µg/Nm ³	12	< 8.1
Dust (total suspended particulates)	230 µg/Nm ³	196	90.28
PM ₁₀	150 µg/Nm ³	18	22
PM _{2.5}	65 µg/Nm ³	15	18
Ammonia (NH ₃)	2 ppm	0.011	0.011
Hydrogen Sulfide (H ₂ S)	0.02 ppm	0.04	0.037

Source: PDAM Tirtawening Laboratory Report (Bandung, May 2019), except for PM₁₀ and PM_{2.5} Sucofindo Laboratory Report (Bekasi, August 2019) for PM₁₀ and PM_{2.5} parameters.

144. **Ambient Noise Level.** GDE Dieng also monitors the ambient noise level at the same stations as those of the ambient air quality. The result of noise monitoring conducted in the last two quarters of 2018 is presented in Figure 4.5, indicating that the noise level of less than 51 dB(A) was recorded at Sikunang as the closest receptor to the existing Dieng Unit 1. This noise level is below the threshold value of 55 dB(A) for residential area stipulated by the Indonesian Government²⁰. Ambient noise levels of up to 74 dB(A) and 57 dB(A), exceeding the set threshold value were monitored at Kepakisan and Karang Tengah on the 4th quarter of 2018. This situation may be attributable to high intensity of household and road traffic. While, elevated noise level measured at the power plant reflects occupational exposure for employees and contractors and is not considered exceedance of ambient noise level.

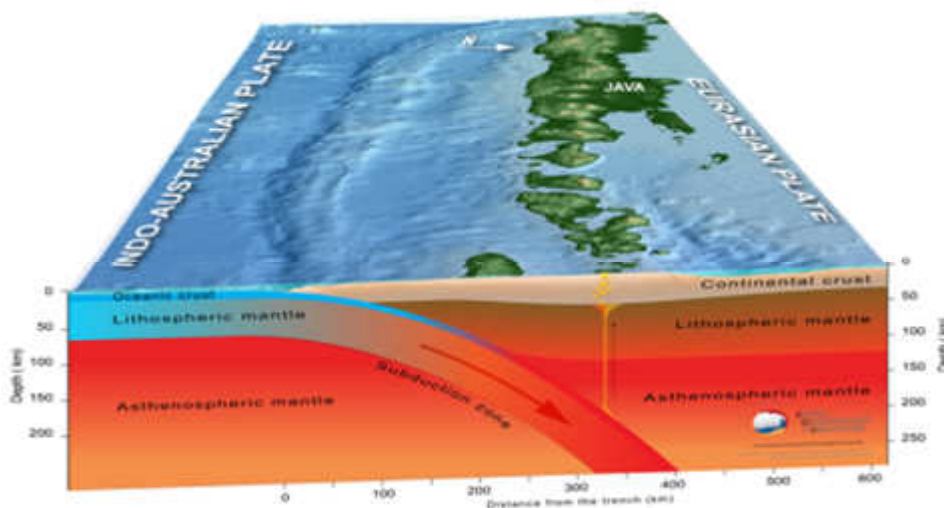
**Figure 4.5: Ambient Noise Levels Measured in 2018**

²⁰ Ministry of Environment decree No. 48/1996 on Ambient Noise Standards.

145. In addition, 24-hours measurement of ambient noise level was undertaken near the village hall of Dieng Kulon village in April 2019 to complement the information for this IEE. The measurement result indicated that noise level of up to 63 dB(A) was calculated for day-time period (06.00 – 22.00), and up to 51 dB(A) at night-time period (22.00 – 06.00), and hence this yields to a calculated, baseline noise level of 61 dB(A) for 24-hour period.

4.2.3 Geology and Topography

146. **Regional geology.** The GDE Dieng project site is geologically located in the Sunda Land and adjacent to the boundary of the Eurasian Plate and the Indo-Australia Plate. The rate of subduction of the Indo-Australia Plate is reportedly 6 to 7 cm/year, with the highest rate reportedly occurring in West Java. The subduction activity has controlled the volcanic activity and structural trend in Java area, comprising North-South (Sunda trend) of late Oligocene age. The Indo-Australian tectonic plate (on the left) dives under the Eurasian plate (on the right) as shown in Figure 4.6.



Source: Earth Observatory of Singapore.

Figure 4.6: Cross-section of Subduction Zone beneath Java, Bali, Lombok, and Sumbawa

147. The surface structure is characterized by the North-South and North northeast – South southwest trends. The deep-seated structure is represented by the Northwest - Southeast and West northwest – East southeast trends. This regional structure provides permeability for fluid accumulation in the reservoir and controls the distribution of heat sources. Figure 4.7 presents the regional tectonic feature of Indonesia, including Central Java where the GDE Dieng project site is located.

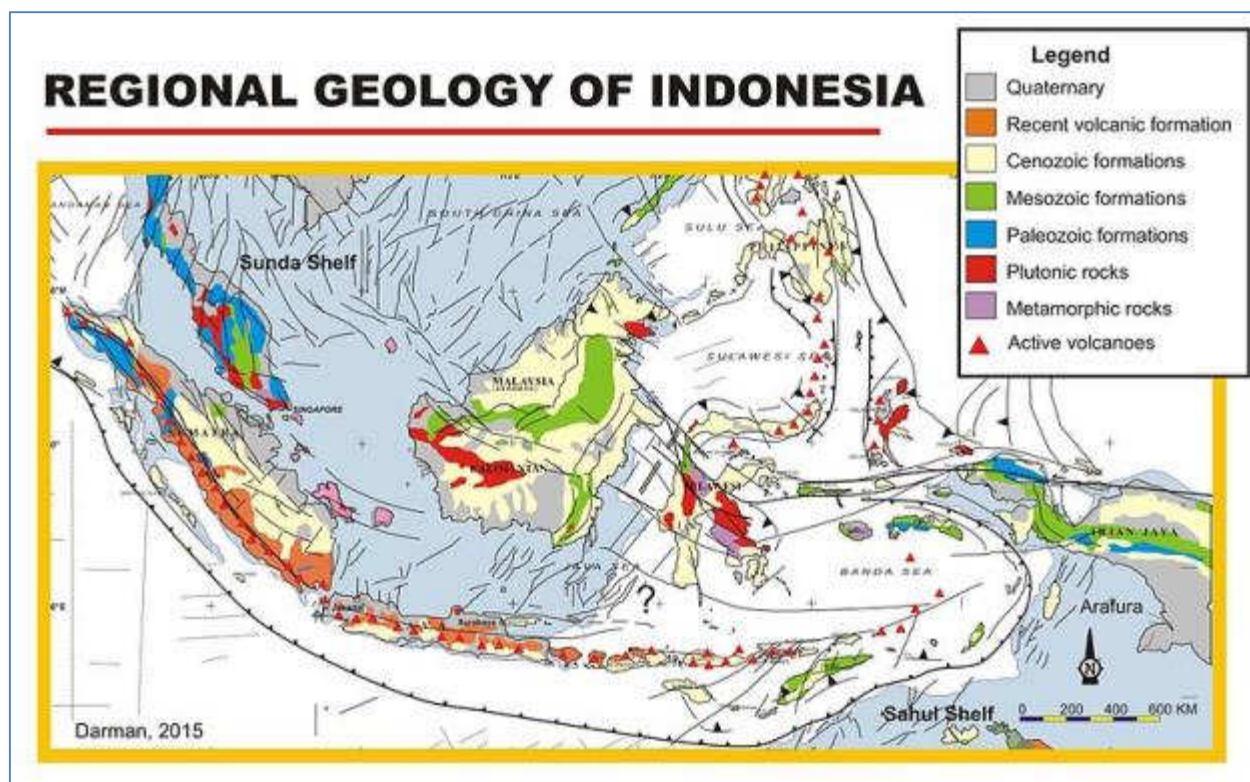


Figure 4.7: Regional Tectonic Features of Indonesia

148. **Local geology.** The Dieng Plateau/Mountain consists of a complex of late Quaternary to recent volcanic stratocones, parasitic vents, and explosion craters that have been hydrothermally active during this century. This is thought to have originated at the junction of two major fracture zones that are represented by major topographic lineaments (Muffler, 1970). The first zone is west trending and extends from the Dieng Mountains 50 km westerly to Mount Slamet. The second zone is represented by a row of young cones, including Mounts Sundoro and Sumbing, extending southeast of the Dieng Mountains for 35 km. Figure 4.8 shows geological features of Dieng Plateau.

149. Referring to Soedharto (2013), the Dieng Mountain consists of Quaternary volcanic rocks aligned similarly to the regional structural features. The surface rocks in this area are covered by Quaternary andesite lava flows and pyroclastic units. The Dieng Volcanic Complex (DVC), which is within the Central part of Java Island, is characterized by a collapse structure containing 17 post intra-caldera eruptive centers. Since the eruption of lava domes and flows in the eastern Dieng Mountains, no deposits of magmatic eruptions, explosive or otherwise, have been identified in this area. Numerous historic and prehistoric phreatic or hydrothermal explosive eruptions have occurred. Some of the eruptions have produced single, steep-walled, circular craters while others have produced a series of connected or elongated craters or fissures. The latest phreatic eruption (volcanic activities) in Dieng Mountains occurred from Sileri Crater in 2017.

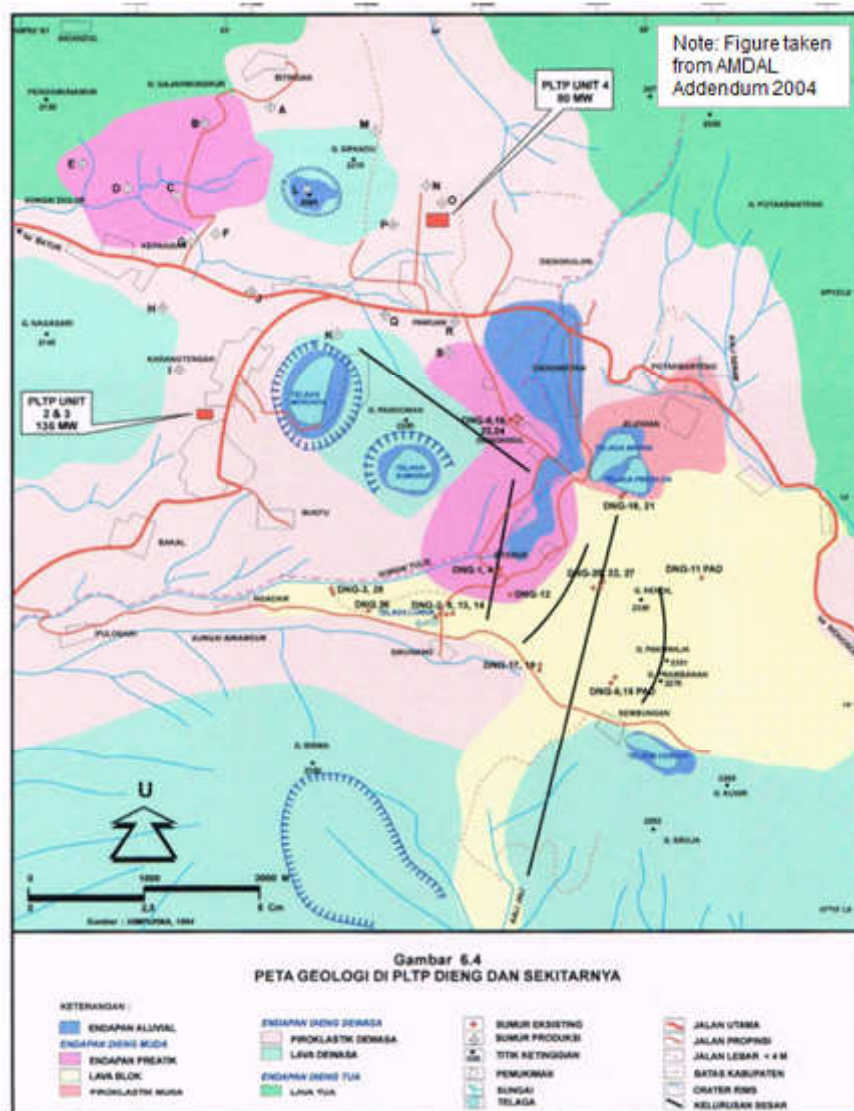


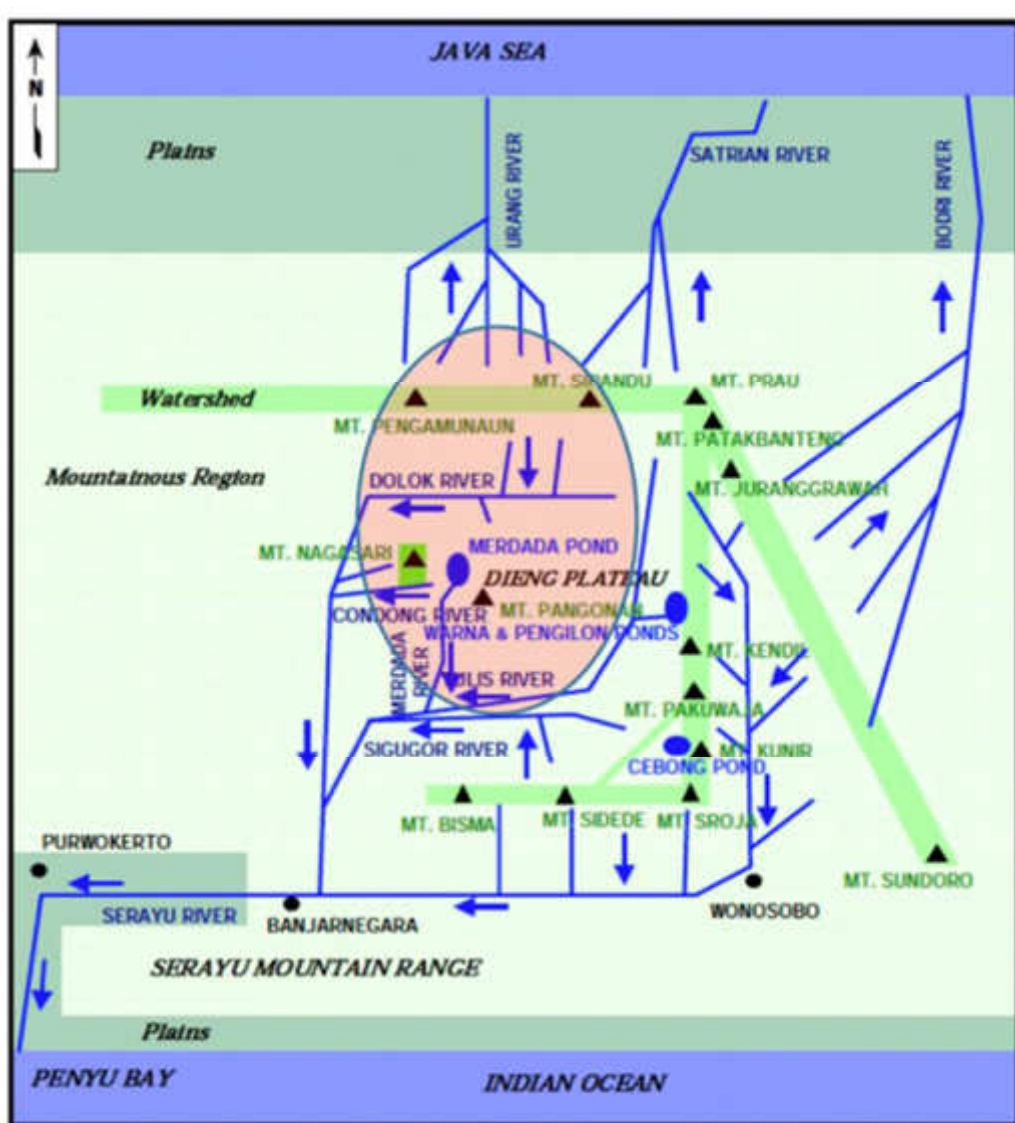
Figure 4.8: Dieng Geological Features

150. **Topography.** The GDE Dieng project area has undulating landscape, ranging from relatively flat to very steep slope in a range of 5° to 43°. The East-West trend extends from Mount Butak to Mountain Prau. The peak of these mountains reaches an elevation between 2,200 and 2,600 meter above sea level. The GDE project area is surrounded by several mountains, among others, Mount Pengamunamun (2,120 m), Mount Gajahmungkir (2,120 m), Mount Kendil (2,350 m), Mount Pakuwaja (2,351 m), Mount Prau (2,556 m), Mount Bismo (2,350 m), and Mount Pongan (2,250 m). The existing and future sites of GDE project areas are at elevation of approximately 1,940 to 2,050 meter above mean sea level.

4.2.4 Hydrology and Water Resources

151. **Hydrology.** The GDE Dieng project area is located in the Dieng mountains landscape with streams and rivers that drain into Tulis and Serayu watersheds. Agriculture relies exclusively on surface water (from precipitation) given the deep depth of freshwater aquifer and high content of

H₂S naturally occurring in many groundwater sources. Irrigation water is supplied from natural lakes, ponds and streams through a dense network of small-diameter irrigation pipes installed and maintained by farmer groups. Given the location of the Dieng Plateau, the catchment area of these natural water bodies is small and as a result seasonal variability is high. The project area is crossed by several streams and rivers. There are several main seasonal streamlets, like Kali Belo and Kali Tulis in the north, Kali Dolok, Kali Sedangdang and Kali Condong on the southwestern, and Kali Merdeka on southern parts that flow into Lake Merdada. Figure 4.9 illustrates the existence of surface bodies and its watersheds in Dieng Plateau.



Source: Dieng Feasibility Study Update, June 2019.

Figure 4.9: Surface Water Bodies in Dieng Plateau

152. Merdada pond is the largest natural pond in the area and located near Well pad #9. The water is acidic and not suitable for drilling uses. Warna and Pengilon ponds are natural ponds inside a crater; even in these cases, their acidic water is not suitable for drilling purposes. Thus, none of the natural ponds is a suitable water source for drilling the wells.

153. Sidolog river is the main river crossing the Sileri area. While long-term water flow rates are not available, the recent *in-situ* measurement conducted by GDE in 2018 indicated a range between 87 L/s (upstream) and 123 L/s (downstream) at this river. The addendum ANDAL (2004) quoted a flow rate of 16 L/s upstream (behind Pertamina office) and 459 L/s downstream (near Kepakisan) of Sidolog river. This river is an important source of water for farmers especially during the dry season.

154. Tulis river is outside the Sileri area, representing the most interesting alternative to Cidolok River as source of freshwater for drilling the wells. The river is about 2.5 km far from Well pad #17 and a water intake has been built and equipped with pumping system. Recent *in situ* measurement indicated a flow rate of 105 L/s (upstream) to 156 L/s (downstream) of the river. The addendum ANDAL (2004) quoted a flow rate of 318 L/s upstream (near Pulosari) and 140 L/s downstream (near Ngadam) of Tulis river. This river is also an important source of water for farmers especially during the dry season.

155. Urang river is located in the North of the Sileri area, beyond the watershed, where agricultural needs are very low; its exploitability would be very useful for drilling in pads 10 and 33; however, its flow rate at the time of the Consultant's survey (March 2019) was extremely low (few liters per second) and surely not sufficient to represent an useful water source.

156. **Hydrogeology.** Based on the hydrogeological map Sheet XII of Bakosurtanal (2004), the Dieng geothermal field is dominated by local productive aquifer. The transmissivity of the aquifer is diverse with deep water tables and springs that discharge with low rates. This aquifer consists of younger volcanic rocks, sedimentary rocks, and volcanic Old Prau. The younger volcanic rocks consist of fresh tuff, agglomerate, volcanic breccia, lava and lahar sediments.

157. The drainage system is dominated by Wonosobo and Karangobar groundwater basin. The Wonosobo basin is approximately located at an elevation of 900 masl -1,200 masl (compared to the elevation of Dieng Project area in a range of approximately 1,800 masl – 2,000 masl). This groundwater basin is estimated to have 210 million m³/year of unconfined groundwater recharge and 8 million m³/year of confined groundwater flow. The Karangobar basin is located at 1,000 masl, and has unconfined groundwater recharges of around 153 million m³/year and confined groundwater flow of 4 million m³/year.

158. **Surface Water Quality.** GDE Dieng conducts quarterly monitoring of river (stream) water quality as the requirement of addendum ANDAL and RKL-RPL (2004) and integral part of its Unit 1 operation. The monitoring stations for water quality samples are at the upstream and downstream parts of Tulis, Putih (Sikunang), and Sidolog (Dolog) rivers. These monitoring stations appear to have been established to identify impacts on water courses that may be impacted by the existing operations.

159. The water samples are analyzed for extensive parameters stipulated by the Indonesian Government typically applied for surface water and groundwater.²¹ The results of water quality analysis for the third (Q3) and fourth quarter (Q4) of 2018 are presented in Table 4.6 and

²¹Government Regulation No. 82/2001 on Water Quality Management and Water Pollution Control, Class II: Water quality standard for recreational purpose, freshwater aqua culture, agriculture, watering, and other purposes requiring similar water quality standard typically applies for surface water; and Ministry of Health Regulation No. 416/1990 on Requirement and Supervision of Water Quality, Attachment II: Clean water standard typically applies for groundwater.

interpreted against threshold values stipulated in the Class II standard of Government Regulation No. 82/2001 as follows:

160. Physical parameters. The concentration of total dissolved solids in most samples is well below the threshold value of 1,000 mg/L, except in one (out of 12) sample collected from Tulis river (upstream) was measured at 1,017 mg/L. Similarly, the concentration of total suspended solids (TSS) in most samples is well below the threshold value of 50 mg/L, except in three samples collected from Tulis river (upstream and downstream) was measured at 158 mg/L and 76.5 mg/L respectively, and that from Sidolog river (downstream) measured at 852 mg/L.

161. Inorganic chemical parameters. 27 chemical parameters were analyzed for the water samples collected at the three rivers mentioned earlier. Out of the 27 parameters analyzed, only seven parameters were measured to have concentrations exceeding their respective threshold values. However, factors contributing to this event were unknown or not described in the related monitoring reports. These seven parameters are as follows:

- Highly elevated concentration of biochemical oxygen demand (BOD) was almost 80 mg/L in one sample collected from Tulis river (upstream) in Q3/2018. The BOD concentrations reduced to up to 5 mg/L in two samples collected from upstream and downstream of Tulis river in Q4/2018, although this is still above the respective threshold value of 3 mg/L.
- One sample collected from Tulis river (upstream) has a concentration of chemical oxygen demand (COD) of 264 mg/L, well above the threshold value of 25 mg/L.
- The concentration of dissolved oxygen (DO) was measured at 1.8 mg/L below the threshold value of 4 mg/L in one sample collected from Tulis river (upstream).
- Nine (out of 12) samples collected from all three rivers have nitrate concentrations in a range of 11 – 28 mg/L, exceeding the threshold value of 10 mg/L.
- The threshold value for copper is set at 0.02 mg/L but the analytical results were reported at <0.04 mg/L. This means that copper concentrations of below 0.04 mg/L in the water samples cannot be detected.
- The concentration of nitrite was measured in a range of 0.12 – 0.87 mg/L in five (out of 12) samples collected from Tulis and Putih rivers, exceeding the threshold value of 0.06 mg/L. The water samples collected from Tulis river consistently shows nitrite concentration above the threshold value.
- The sulfide (H₂S) concentration in all samples collected from the three rivers was detected above the threshold value of 0.002 mg/L.

162. Microbiological parameters. Most of the water samples from the three rivers mentioned earlier were detected to have low to moderate number of fecal and total coliform colony, and this was below the threshold values of 1,000 colonies/100 ml and 5,000 colonies/100 ml respectively. An exceptionally elevated number of fecal and total coliform, reaching up to 6 million colonies and 7.6 million colonies respectively per 100 ml of water sample was reported for one sample collected from Tulis river (upstream) in Q3/2018. These numbers reduced to 3,200 and 5,500 per 100 ml of water samples for fecal and total coliform respectively for the sample collected from Tulis river in Q4/2018. Elevated fecal and total fecal coliform colonies of 24,000 and 34,000 per 100 ml of water samples were detected in the samples collected from Sidolog river (downstream).

Table 4.7: Water Quality Monitoring Results of Tulis, Putih, and Sidolog Rivers

(Note: Concentrations exceeding the threshold value are printed in bold.)

[illegible]

Parameter	Threshold Value ¹	Tulis River (Q3/2018)		Tulis River (Q4/2018)		Putih River (Q3/2018)		Putih River (Q4/2018)		Sidolog River (Q3/2018)		Sidolog River (Q4/2018)	
		Upstream	Down stream	Upstream	Down stream	Upstream	Down stream	Upstream	Down stream	Upstream	Down stream	Upstream	Down stream
Manganese (Mn)	-	0.16	< 0.08	0.15	0.11	0.41	< 0.08	0.41	0.22	< 0.08	< 0.08	< 0.08	< 0.08
Mercury (Hg)	0.002 mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.011	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Zinc (Zn)	0.05 mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chloride (Cl ⁻)	600 mg/L	72.9	9.72	12	20	124	124	14	125	27.2	56.4	52	66
Cyanide (CN)	0.02 mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoride (F)	1.5 mg/L	< 0.065	0.339	0.133	< 0.065	< 0.065	0.254	< 0.065	< 0.065	< 0.065	< 0.065	0.13	< 0.065
Nitrite (NO ₂ -N)	0.06 mg/L	0.12	0.21	0.85	0.87	0.12	0.003	< 0.003	< 0.003	0.010	0.035	< 0.003	< 0.003
Sulfate (SO ₄ ²⁻)	-	14.3	6.97	1.83	1.37	4.00	9.00	2.47	3.59	1.35	2.41	1.39	1.17
Free chlorine	0.03 mg/L	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019	< 0.019
Sulfide (as H ₂ S)	0.002 mg/L	0.271	0.098	< 0.016	< 0.016	0.116	0.080	< 0.016	< 0.016	0.092	0.086	< 0.016	< 0.016
Microbiological													
Fecal coliform	1,000 colonies/100 ml	6,000,000	200	3,200	210	710	190	52	29	0	55	310	24,000
Total coliform	5,000 colonies/100 ml	7,600,000	600	5,500	2,500	4,000	2,200	310	250	430	540	450	34,000

Source: GDE Dieng RKL-RPL monitoring reports (2nd Semester of 2018).

Note: ¹Government Regulation No. 82/2001, Class II Water Quality Standard.

163. **Stream water quality near Well pad #29.** Water sample was collected in April 2019 for analysis from the stream within the proximity of Well pad #29 to complement the information required for this IEE. The analytical result of this sample is presented in Table 4.8, indicating that none of the parameters analyzed exceeds their respective threshold values.

Table 4.8: Stream Water Quality (Well pad #29)

Parameter	Threshold Value ¹	Results
Physical		
Temperature	°C	20.2
Total dissolved solid (TDS)	1,000 mg/L	249
Chemical		
pH	6.0 – 9.0	7.5
Sulfate (SO ₄ ²⁻)	-	11.2
Iron (Fe)	-	0.0863
Dissolved oxygen	>4.0 mg/L	8.5
Chrome (Cr ⁶⁺)	0.05 mg/L	< 0.021
Lead (Pb)	0.03 mg/L	< 0.02495
Nitrate (NO ₃ -N)	10 mg/L	7.4
Arsenic (As)	1 mg/L	< 0.0002
Cadmium (Cd)	0.01 mg/L	< 0.00618

Source: PDAM Tirtawening Laboratory (Bandung, May 2019)

Note: ¹Government Regulation No. 82/2001, Class II Water Quality Standard.

164. **Ground water quality.** Groundwater from the community wells were sampled at Karang Tengah (water tap at the mosque), Sikunang, and Pranten (both collected from water taps at the resident houses) for subsequent analyses. Results of analyses are given in Table 4.9. The concentrations of most parameters analyzed do not exceed their respective threshold values.

Table 4.9: Groundwater Quality of Community Wells

Parameter	Threshold Value ¹	Karang Tengah	Sikunang	Pranten
Physical				
Smell	No smell	No smell	No smell	No smell
Total dissolved solid (TDS)	1,500 mg/L	139	114	338
Chemical				
Iron (Fe)	1 mg/L	0.0454	0.0088	0.0366
Arsenic (As)	0.05 mg/L	< 0.0002	< 0.0002	< 0.0002
Cadmium (Cd)	0.005 mg/L	< 0.00618	< 0.00618	< 0.00618
Nitrate (NO ₃ -N)	10 mg/L	3.597	9.698	4.461
pH	6.5 - 9.0	7.4	7.6	6.2
Chrome (Cr ⁶⁺)	0.05 mg/L	< 0.021	< 0.021	< 0.021
Sulfate (SO ₄ ²⁻)	400 mg/L	3.44	2.95	2.95
Lead (Pb)	0.05 mg/L	< 0.025	< 0.025	< 0.025

Source: PDAM Tirtawening Laboratory (Bandung, May 2019).

Note: ¹Ministry of Health Regulation No. 416/1990, Attachment II: Clean Water Standard.

165. **Rainwater quality.** To have an early indication whether acid rain has occurred in Dieng area, two rainwater samples were collected at Karang Tengah and Pranten villages for subsequent analyses of pH, nitrate (NO₃-N), and sulfate (SO₄²⁻). The results (Table 4.10) indicate

that the rainwater analyzed has a neutral pH around 7 – 8, and relatively low concentration of nitrate and sulfate. There are no standards for rainwater that have been stipulated by the Indonesian Government. Review of the acid rain fact sheet published by the Safe Drinking Water Foundation²² indicates that acid rain usually has a pH between 4.2 and 4.4. However, the fact sheet does not mention the threshold values of nitrate and sulfate for rainwater. For comparison, orange juice/soda water has a pH of around 3, whereas distilled water has a pH of around 7. Based on this reference, the rainwater analyzed for Dieng in 2019 cannot be considered acid rain. Table 4.10 presents the results of rainwater analysis.

Table 4.10: Rainwater Quality

Parameter	Unit	Karang Tengah	Pranten
pH	-	7.62	7.32
Nitrate (NO ₃ -N)	mg/L	2.56	2.14
Sulfate (SO ₄ ⁻²)	mg/L	5.25	7.15

Source: PDAM Tirtawening Laboratory (Bandung, May 2019).

166. **Soil.** Andosol is the primary type of soil commonly observed in the Dieng project area that has a thickness of subsoil layers (sola) in a range of 60 – 90 cm and there are cases the thickness reaches up to 120 cm. The texture of this soil type comprises loam, silt, and clay loam in the form of fine and loose granular, moderate consistency, and slight plasticity. Patches of latosol created from tuff lapilli that has been eroded were also identified. Latosol has a subsoil layer in the range of 20 cm, comprising clay, fine granular, and slight plasticity.

167. Soil samples were collected from the following locations i.e., Slope of Gajahmungkur mountain and within the existing well pads of DNG-9, DNG-6, and DNG-2 in 2003/2004 (Revised ANDAL, 2004) for analyses of its nutrient and fertility. The result of this analysis is presented in Table 4.11, indicating that the fertility level of the soil at the sampling sites varies from low to moderate.

Table 4.11: Analytical Results and Fertility Status of the Soil Samples

Sampling Station (Code)	Soil Layer	Chemical Properties	Fertility Level
Gajahmungkur Mountain (BT1)	Upper horizon	Slightly acidic soil Very high carbon organic (C-organic), moderate phosphate oxide (P ₂ O ₅) and sodium (Na), and low potassium oxide (K ₂ O) High cation exchange capacity Moderate alkalinity	Moderate
	Lower horizon	Slightly acidic soil Very high carbon, low phosphate oxide, and potassium oxide Moderate calcium Low magnesium, potassium, and sodium High cation exchange capacity Moderate alkalinity	Low
Well pad DNG-9 (BT2)	Upper horizon	Acidic soil High carbon organic and phosphate oxide	Moderate

²²<https://www.safewater.org/fact-sheets-1/2017/1/23/acid-rain-fact-sheet>

Sampling Station (Code)	Soil Layer	Chemical Properties	Fertility Level
		Low potassium High calcium and magnesium Moderate potassium and sodium High cation exchange capacity Moderate alkalinity	
Well pad DNG-6 (BT3)	Upper horizon	Acidic soil High carbon organic and phosphate oxide Low potassium oxide Moderate calcium Low magnesium, potassium, and sodium High cation exchange capacity Moderate alkalinity	Moderate
	Lower horizon	Acidic soil High carbon organic and phosphate oxide Low potassium oxide Low calcium, magnesium, potassium, and sodium Low cation exchange capacity and alkalinity	Low
Well pad DNG-6 (BT4)	Upper horizon	Slightly acidic soil High carbon organic and phosphate oxide Low potassium oxide Moderate calcium Low magnesium, potassium, and sodium High cation exchange capacity Moderate alkalinity	Moderate
	Lower horizon	Acidic High carbon organic Low phosphate and potassium oxides Very low calcium, magnesium, potassium, and sodium Very low cation exchange capacity and alkalinity	Low

Source: Revised Dieng ANDAL (2004).

168. Based on Wadahningrum, et.al. (2015), a monoculture system by plating potatoes as the main commodity has been practiced over time. Consequently, this practice has resulted in reduced nutrients in the soil. Land clearing, including in forest area, for planting potatoes has also contributed to increased soil erosion and the potential for landslide. The soil erosion rate within the project site was rated at 464 tons/hectares/year and considered high based on the classification issued by the Indonesian Ministry of Forestry and Plantation (1998).

169. As part of this IEE, soil samples were collected at Karang Tengah, Sikunang, and Pranten. The result of the soil analyses for pH, nitrate, and sulfate analysis is presented in Table 4.12, indicating that all soil samples are slightly acidic, moderate concentration of nitrate, and low concentration of sulfate.

Table 4.12: Soil Analytical Results - Karang Tengah, Sikunang, and Pranten

Parameter	Value ¹	Karang Tengah	Sikunang	Pranten
pH	5.5 – 6.5 (slightly acidic)	6.28	6.01	6.31
Nitrate (NO ₃ -N)	2 ppm (low) 4 ppm (moderate)	3.20	2.72	4.26
Sulfate (SO ₄ ⁻²)	20 ppm (low)	8.21	9.42	10.0

Source: PDAM Tirtawening Laboratory (Bandung, May 2019)

Note: ¹ Soil assessment criteria – technical guidance (Soil Research Centre, Bogor, 2009).

170. **Natural hazards.** The existence of active volcanoes in Central Java and other parts of Indonesia making the country as among the active seismic zone within the Pacific Ring of Fire. The seismic activity in the country is resulted from subduction zones of the Eurasian Plate, Pacific Plate, and Indo-Australian Plate as the main active tectonic plates in the world.

171. For centuries, volcanic activities at Dieng Plateau has been dominated by recurrent phreatic eruptions and geothermal related manifestation (i.e, fumaroles, solfataras, mud pools, and hot springs). The Dieng volcano is noted for the release of carbon dioxide and other hazardous gases, which sometimes at high concentrations and prolonged exposure could result in fatalities and destroy the surrounding vegetation (known as 'death valley', phenomenon). The volcano is composed of two strato volcanoes (Butak Petarangan and Dieng) and many craters. Warm acidic lakes fill some of the craters. Volcanic cones at Dieng include the following: Bismo, Srojo, Binem, Pangonan, Merdodo, Pagerkandang, Nogosari, Petarangan, Telogo Dringo, Pakuwaja, Kendil, Kunir, and Prambanan. Historical eruptions occurred in Dieng Plateau are presented in the Table 4.12.

Table 4.13: Historical Eruptions of Dieng Plateau

Year	Eruption Events
1944	Sileri Crater
1945	Sikidang crater
1964	Sileri Crater
1979	Sinila Crater including CO ₂ emission
1979	Timbang Crater including high concentration of CO ₂ and volcanic earthquake
2003	Sibanteng crater
2009	Sileri crater
2017	Sileri crater
Source: https://id.wikipedia.org/wiki/Dieng	

172. Based on the Indonesia Hazard Map (Figure 4.10), Dieng Plateau is located in an area that has less hazards potential (marked in green) compared to other areas in Sumatera or Sulawesi (marked in red).

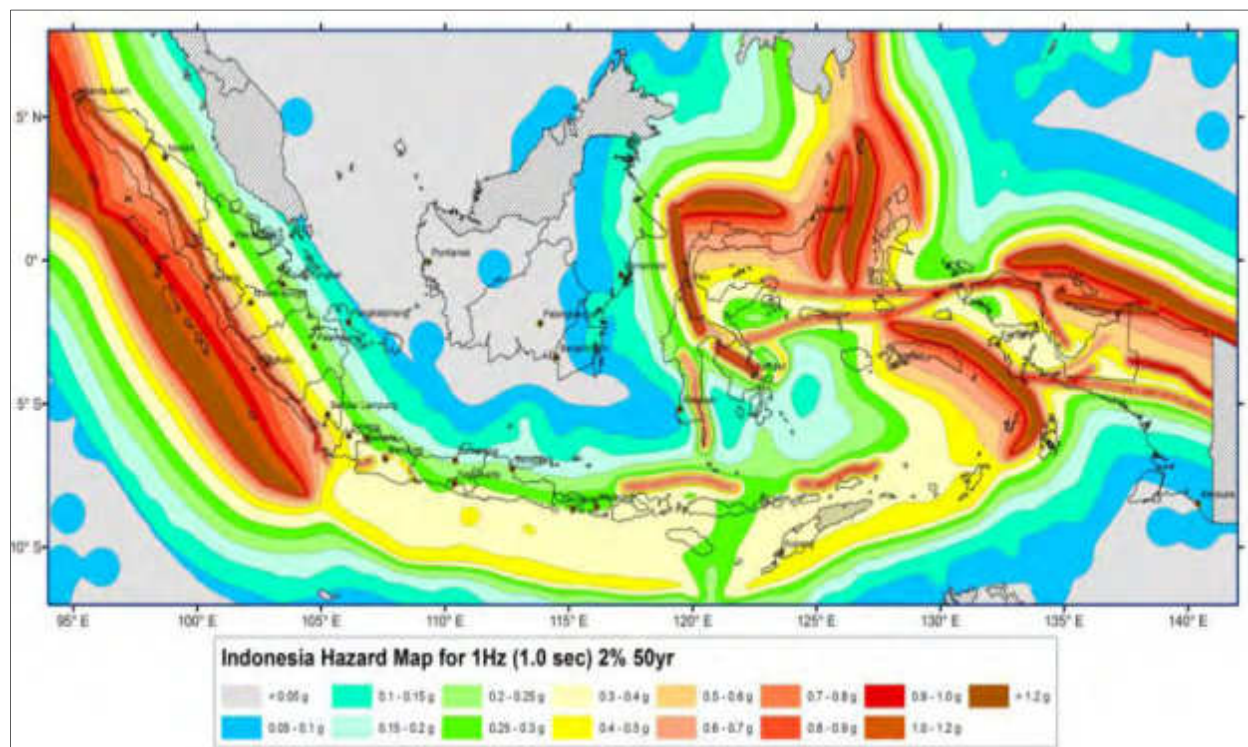


Figure 4.10: Indonesia Seismic Hazard Map

4.3 Biological Environment

173. Dieng Unit 2 project area (including the existing Dieng Unit 1) and most areas of Dieng Plateau are located in a mix of predominantly dry land agriculture ecosystem planted to potatoes and vegetables, and plantation forest. The agricultural area comprises Modified Habitat in a broader landscape which has an extensive tract of forested natural habitat (the Dieng Mountains). The following subsections describe terrestrial flora and fauna based on the biodiversity study conducted in 2018, and aquatic habitat within the project area based on the semi-annual RKL-RPL monitoring. In addition, a critical habitat assessment of the project area and a bird survey were done within March 2019 to May 2019 to ensure that species of conservation status both from the national and global perspective (i.e., IUCN) are not adversely affected by the design and operation of the project.

4.3.1 Terrestrial Flora

174. **Ecosystem and Habitat.** The 2018 biodiversity study recorded that most of Dieng Plateau are planted with vegetable crops in areas that have a slope of up to 70%. There is a relatively small fraction of plantation forest mixed with shrubs. The dominant plants species are Green wattle/soga (*Acacia decurens*), 'Terong Belanda' (*Cyphomandra betacea*), Mediterranean cypress (*Cupressus sempervirens*), and 'Kecubung gunung' (*Brugmansia soaviolens*). Several species found in the plantation forest ecosystems include 'Kemlandingan gunung'

(*Paraserianthes lapantha*), and 'Pakis tiang' (*Cyathea contaminans*). Low richness of understory species such as 'Roro ireng' (*Eupatorium riparium*), 'Goletrak' (*Borreria latifolia*), 'Rumput bulu' (*Arundo donax*), *Carex* sp. and *Gahnia* sp. was observed. The dominant vegetation planted are potato, cabbage, carrot, and paprika. Typical ecosystem and habitat observed in Dieng Plateau are presented in Figure 4.11. Dieng Unit 2 will be constructed at the GDE-owned land in Karang Tengah Village.



Potato farming at Karang Tengah Village



Bushes and trees at Karang Tengah Village



Mix of potato farming, plantation forest, and riparian at Dieng Kulon Village



Potato farming near Telaga Cebong, Sembungan Village

Figure 4.11: Typical Ecosystem and Habitat

175. The biodiversity study covered 19 stations within the Dieng Plateau, particularly the ecosystem and habitat of villages within the existing and future GDE project areas as presented in Figure 4.12.

Table 4.14: Occurrence and Relative Frequency of Tree Species

No.	Family	Latin Name	Local Name	Occurrence	Relative Frequency (%)
1	Mimosaceae	<i>Acacia decurens</i>	Soga	19	14.62
2	Solanaceae	<i>Cyphomandra betacea</i>	Terong belanda	19	14.62
3	Solanaceae	<i>Brugmansia soaviolens</i>	Kecubung gunung	13	10
4	Cupressaceae	<i>Cupressus sempervirens</i>	Cemara lilin	12	9.23
5	Theaceae	<i>Schima walicii</i>	Puspa	8	6.15
6	Myrtaceae	<i>Eucalyptus cf. urophylla</i>	Ampupu, Eukaliptus	7	5.38
7	Mimosaceae	<i>Calliandra calothyrsus</i>	Kaliandra merah	6	4.62
8	Solanaceae	<i>Brugmansia candida</i>	Kecubung gunung	6	4.62
9	Casuarinaceae	<i>Casuarina junghuhniana</i>	Cemara gunung	4	3.08
10	Casuarinaceae	<i>Casuarina sumatrana</i>	-	4	3.08
11	Meliaceae	<i>Toona sureni</i>	Kayu Suren	4	3.08
12	Cupressaceae	<i>Thuja occidentalis</i> L.	-	3	2.31
13	Myricaceae	<i>Myrica javanica</i>	Wuru ketek, Picisan	3	2.31
14	Araliaceae	<i>Aralia dasyphylla</i>	-	2	1.54
15	Araliaceae	<i>Aralia javanica</i>	-	2	1.54
16	Cupressaceae	<i>Tsuga chinensis</i>	-	2	1.54
17	Mimosaceae	<i>Paraserianthes lophantha</i>	Kemlandingan gunung	2	1.54
18	Rosaceae	<i>Prunus persica</i>	Persik	2	1.54
19	Solanaceae	<i>Cestrum nocturnum</i> L.	Arum dalu	2	1.54
20	Aceraceae	<i>Acer laurinum</i>	Ki kanada	1	0.77
21	Actinidaceae	<i>Saurauia bracteosa</i>	Kayu lotrok	1	0.77
22	Araliaceae	<i>Schefflera</i> sp.	Walisono	1	0.77
23	Fagaceae	<i>Lithocarpus densiflorus</i>	Pasang	1	0.77
24	Moraceae	<i>Morus alba</i> L.	-	1	0.77
25	Pinaceae	<i>Pinus merkusii</i>	-	1	0.77
26	Rubiaceae	<i>Coffea</i> sp.	-	1	0.77
27	Salicaceae	<i>Salix</i> sp.	Dedalu	1	0.77
28	Sapindaceae	<i>Dodonaea viscosa</i> (L.)	Kayu tesek	1	0.77
29	Theaceae	<i>Camelia sinensis</i>	Teh	1	0.77

178. Based on the 163 flora species identified in the biodiversity study, 14 species are local to Dieng, 24 species associated with the presence of crater, 55 species of Java highland area, 16 economically valuable species, and 15 introduced species. Three of 15 introduced species are invasive i.e., Soga (*Acacia decurrens* Willd.), Eukaliptus (*Eucalyptus cf. urophylla* Blume.) and Pinus (*Pinus merkusii* Jungh. & de Vriese). The invasive alien species are threats to local species and ecology. The low number of ferns species (i.e., 15 species) is not usual for the mountainous area. Less number of ferns indicates that the area is less humid due to low number of trees caused by logging.

179. The canopy coverage in the surveyed areas is also low to moderate due to most of the forest areas have been cleared and planted with potato and other vegetable crops. As a result, the number of Dieng Plateau's local vegetation has been decreased. Only few local species can

be found at the surveyed areas, including *Saurauia sp.* (Actinidaceae), *Schefflera spp.* (Araliaceae), *Lithocarpus spp* (Fagaceae) *Myrica sp.* (Myricaceae), *Engelhardia spicata* (Juglandaceae) and *Vaccinium sp* (Centigi kawah; Ericaceae).

4.3.2 Terrestrial Fauna

180. The 2018 Biodiversity Survey identified 49 species of fauna recorded at the surveyed areas, consisting 6 species of mammals, 2 species of amphibians, 35 species of birds, and 6 species of fishes. The list of mammal and amphibian species identified at the surveyed sites is presented in Table 4.15. Note that these mammal and/or amphibian species are identified at 11 out of 19 surveyed areas during the biodiversity survey.

181. **Mammals.** The civet, squirrel, sunda procupine and Asian small mongoose are categorized as having the Least Concern status. Due to massive conversation of plantation forest area, including areas of very steep slope, to dry agricultural practices, the biodiversity of flora in the surveyed area is low. This has resulted in that wild boar, porcupine, and small mongoose come to the farm areas for feeding at night time.

182. **Herpetofauna.** Only two species of amphibians were observed at the surveyed areas. Since amphibians are cold-blooded animal, only few species can adapt to the weather condition of Dieng Plateau. *Microhyla palmipes* are found in the stagnant water and 'Kongkang kolam' (*Chalcorana chalconota*) found at vegetation in Merdada lake. Palmated chorus frog is recorded quite widespread in the surveyed areas. No reptile species is recorded during the biodiversity study.

Table 4.15: Mammals and Amphibian Species

No.	English Name (Local Name)	Scientific Name	GOI	IUCN/CITES
Class: Mammals				
1	Small Asian Mongoose (Garangan)	<i>Herpestes javanicus</i>	-	LC
2	Sunda Procupine (Landak)	<i>Hystrix javanica</i>	P	LC
3	Plantain Squirrel (Bajing Kelapa)	<i>Callosciurus notatus</i>	-	LC
4	Wild boar (Babi hutan)	<i>Sus scrofa</i>	-	LC
5	Common Palm Civet (Musang Luwak)	<i>Paradoxus hermaphroditus</i>	-	LC
Class: Amphibian				
1	Palmated chorus frog (Pencil berselaput)	<i>Myrohyla palmipes</i>	-	LC
2	Schlegel's frog (Kongkang kolam)	<i>Chalcorana chalconota</i> .	-	LC

Notes:

P: Protected by Indonesia Decree of MoEF No. P.92/2018

IUCN Status: LC: Least Concern; CR: Critically Endangered

CITES: I=Appendix I; II=Appendix 2

183. **Avifauna (Bird).** The biodiversity survey recorded 35 species (of 24 families) of birds at the surveyed areas (see Table 4.15). Eight bird species are protected under the Indonesia Regulation, including 'Elang Hitam' (*Ictinaetus malayensis*), 'Alap alap sapi' (*Falco moluccensis*), 'Kipasan Belang' (*Rhipidura javanica*), 'Takur tulang tumpuk' (*Psilopogon javanensis*), 'Burung Madu Sriganti' (*Cinnyris (Nectarinia) jugularis*), 'Cekakak Sungai' (*Todirhamphus chloris*), 'Cekakak

Belukar' (*Halcyon smyrnensis*), and 'Cekakak Jawa' (*Halcyon cyanoventris*). This relatively low diversity of birds at the surveyed areas correspond with minimal food sources provided by the existing plantation forests.

Table 4.16: Bird Species Identified

No	Family English Name (Local Name)	Scientific Name	GOI	IUCN/CITES
ACCIPITRIDAE				
1	Black eagle (Elang Hitam)	<i>Ictinaetus malayensis</i>	P	LC
ALCEDINIDAE				
2	Javan kingfisher (Cekakak Jawa)	<i>Halcyon cyanoventris</i>	P	LC
3	Collared kingfisher (Cekakak Sungai)	<i>Halcyon smyrnensis</i>	P	LC
4	Collared kingfisher (Cekakak Sungai)	<i>Todirhamphus chloris</i>	P	LC
5	Edible nest swiftlet (Walet Sarang Putih)	<i>Aerodramus (Collocalia) fuciphagus</i>	-	LC
6	Cave swiftlet (Walet Sapi)	<i>Collocalia inchi</i>	-	LC
7	Little swiftlet (Kapinis Rumah)	<i>Apus affinis</i>	-	LC
8	Asian palm swift (Walet Palembang-Asia)	<i>Cypsiurus balasiensis</i>	-	LC
9	Small minivet (Sepah kecil)	<i>Pericrocotus cinnamomeus</i>	-	LC
10	Spotted dove (Tekukur biasa)	<i>Spilopelia (Streptopelia) chinensis</i>	-	LC
11	Plainive cuckoo (Wiwik Kelabu)	<i>Cacomantis merulinus</i>	-	LC
12	Rusty-breast cuckoo (Wiwik Uncuing)	<i>Cacomantis sepulcralis (variolosus)</i>	-	LC
13	Greater coucal (Bubut besar)	<i>Centropus sinensis</i>	-	LC
14	Asian koel (Tuwur Asia)	<i>Eudynamis scolopaceus</i>	-	LC
15	Scarlet-headed flowerpecker (Cabai Jawa)	<i>Dicaeum trochileum</i>	-	
16	Spotted kestrel (Alap-alap Sapi)	<i>Falco moluccensis</i>	P	LC
17	Pacific swallow (Layang- layang batu)	<i>Hirundo tahitica</i>	-	LC
18	Long-tailed shrike (Bentet Kelabu)	<i>Lanius schach</i>	-	LC
19	Striated grassbird (Cica Koreng Jawa)	<i>Megalurus palustris</i>	-	LC
20	Black-banded barbet (Takur Tulung tumpuk)	<i>Psilopogon (Megalaime) javensis</i>	-	NT
21	<i>Cyornis banyumas</i>	Sikatan Cacing/Hill blue flycatcher	-	LC

No	Family English Name (Local Name)	Scientific Name	GOI	IUCN/CITES
22	Malaysian pied fantail (Kipasan Belang)	<i>Rhipidura javanica</i>	-	LC
23	Pied bush chat (Decu belang)	<i>Saxicola caprata</i>	-	-
24	Olivebacked sunbird (Burung Madu Sriganti)	<i>Cinnyris (Nectarinia) jugularis</i>	-	LC
25	Black-naped oriole (Kepodang)	<i>Oriolus chinensis</i>	-	LC
26	Eurasian tree sparrow (Burung Gereja Erasia)	<i>Passer montanus</i>	-	LC
27	Red junglefowl (Ayam Hutan Merah)	<i>Gallus gallus</i>	-	LC
28	White-headed munia (Bondol Haji)	<i>Lonchura maja</i>	-	LC
29	Sooty-headed bulbul (Cucak Kutilang)	<i>Pycnonotus aurigaster</i>	-	LC
30	Common moorhen (Mandar batu)	<i>Gallinula chloropus</i>	-	LC
31	Javan myna (Jalak kebo)	<i>Acridotheres javanicus</i>	-	VU
32	Bar-winged prinia (Perenjak Jawa)	<i>Prinia familiaris</i>	-	-
33	Olive-backed tailorbird (Cinenen Jawa)	<i>Orthotomus sepium</i>	-	LC
34	Common buttonquail (Gemak Tegalan)	<i>Turnix sylvatica</i>	-	LC
35	Oriental white-eye (Kacamata Biasa)	<i>Zosterops palpebrosus</i>	-	LC

Notes:

GOI: Protected by the MoEF Regulation No. P.92/2018;

IUCN Status: LC: Least Concern; NT: Near Threatened; VU: Vulnerable; E: Endangered; CR: Critically Endangered;

CITES: I=Appendix I; II=Appendix 2

184. In addition to the results of biodiversity study described above, an survey of migratory birds of prey was conducted in March 2019 using vantage point method. The survey indicated that the abundance of this kind of bird is very low, with the two species recorded are Oriental Honey-buzzards (*Pernis ptilorhynchus*) and Chinese Sparrow Hawks (*Accipiter gularis*). Further, the survey suggested that the southern part of Dieng Mountain is a minor route for migratory raptors. The Oriental Honey-buzzards flying through this area during the migration season are estimated around 18 individuals and the Chinese Sparrow Hawks around 12 individuals. Figure 4.13 shows the bird of prey observed. The full assessment is presented in Appendix 5b.



Figure 4.13: Oriental Honey-buzzards Observed

185. Table 4.16 presents the number of birds of prey observed in a week at certain height and those extrapolated to estimate the total individual during the migration period. The height band of 0 – 50-meter is considered high-risk zone, while that of 50 – 100-meter is low risk zone in term of potential for bird collision with a physical structure such as power transmission line and its tower, and the tower of base transceiver station. Two birds of prey were observed flying at these height bands and beyond.

Table 4.17: Migratory birds of prey (Baskoro, 2019)

Name of Birds	Birds Count within Each Height Band			Total Numbers Observed in a Week	Extrapolated numbers
	0 - 50 m	50 - 100 m	>100 m		
Oriental Honey-	-	-	3	3	18
Chinese Sparrow Hawks	1	1	1	3	12

4.3.3 Aquatic Biota

186. **Phytoplankton.** The GDE's Dieng semi-annual environmental monitoring reports of the second semester of 2018 recorded two classes of phytoplankton, i.e., Bacillariophyceae (5 species) and Cyanophyceae (3 species). The highest abundance species is *Chroococcuss sp* found at all sampling stations. The highest number of phytoplankton was recorded at Sidolog River. Based on the genera occurrence (present-absent) distribution, one genera from Bacillariophyceae (*Coscinodiscus sp.*) and *Chroococcus sp.* and *Microcystis sp.* were found evenly distributed at all sampling stations. The results of phytoplankton analysis from six monitoring sites at Tulis river, Putih river, and Sidolog river and calculation of relevant indices are presented in Table 4.18.

187. The phytoplankton diversity index (H') was in a range of 2.20 – 2.49; equitability index of 0.94 - 0.97; and dominance index of 0.19 – 0.23 are calculated for the six sampling stations. The high values of equitability index (>0.5) generally indicate there is no dominant genera of benthos in the habitat at all sampling locations as supported by low dominancy index (C). Based on these indices, the phytoplankton community can be considered at stable condition.

Table 4.18: Phytoplankton Occurrence and Distribution

No	Class Scientific Name	Tulis River	Putih River	Sidolog River
BACILLARIOPHYCEAE				
1	<i>Coscinodiscus sp.</i>	40 – 64	40 – 56	40 – 56
2	<i>Cyclotella sp</i>	5 – 16	24	32
3	<i>Diatoma sp.</i>	-	32 – 40	-
4	<i>Nitzschia sp.</i>	15 – 48	-	40 – 56
5	<i>Fragillaria sp.</i>	17 – 56	16 - 24	-
CYANOPHYCEAE				
1	<i>Chroococcus sp.</i>	28 – 88	25 – 64	72 – 80
2	<i>Dactylococcopsis sp.</i>	-	-	24
3	<i>Microcystis sp.</i>	23 – 72		72 - 80
	Number of taxa (S)	6	6	5
	Abundance range (cell/liter)	100 – 320	248 – 256	272 – 280
	Diversity index range (H')	2.43 – 2.49	2.44 – 2.47	2.20 – 2.25
	Equitability index range (E)	0.94 – 0.96	0.94 – 0.96	0.95 – 0.97
	Dominance index range (D)	0.19 – 0.20	0.19 – 0.20	0.21 – 0.23

188. **Zooplankton.** Four genera of zooplankton, comprising two classes i.e., Crustacea and Ciliata were found at the sampling locations. The number of taxa among the sampling locations was in a range of 2 to 4. The abundance falls between 136 individuals/liter at Tulis river and 192 individual/liter at Sidolog river. The most abundance species at the sampling locations was *Ciliata* reaching up to 112 individuals/liter at Sidolog river. This species was recorded at all sampling stations. Based on the genera occurrence (presence or absence) distribution, one genera from Crustaceae (*Cyclops sp.*) and three genera from Ciliata (*Ciliata*, *Urostyla sp.* and *Didinium sp.*) were found evenly distributed at all sampling locations. The results of phytoplankton analysis from six monitoring sites at Tulis river, Putih river, and Sidolog river and calculation of relevant indices are presented in Table 4.19.

189. The benthos diversity index (H') was in a range of 0.92 – 1.45; equitability index of 0.94 - 0.97; and dominance index of 0.44 – 0.55 are calculated for the six sampling stations. The high values of equitability index (>0.5) generally indicate there is no dominant genera of benthos in the habitat at all sampling locations as supported by low dominancy index (C). Relatively high equitability index and low dominancy index were noted at all sampling locations. These results show that there are no dominant genera of macrobenthos at the sampling stations, and therefore the macrobenthos community can be considered in a stable condition.

Table 4.19: Benthos Occurrence and Distribution

Class Scientific Name	Tulis River	Putih River	Sidolog River
CRUSTACEA			
<i>Cyclops SP.</i>	8	-	8 – 16
CILIATA			
<i>Ciliata</i>	80 – 96	88 – 96	104 – 112
<i>Urostyla sp.</i>	40 – 48	56 – 64	56 – 64

Class Scientific Name	Tulis River	Putih River	Sidolog River
<i>Didinium sp.</i>	8	-	-
Number of taxa (S)	2 – 4	2	3
Abundance range (cell/liter)	136 – 144	152	168 - 192
Diversity index range (H')	0.92 – 1.45	0.95 – 0.98	1.16 – 1.28
Equitability index range (E)	0.72 – 0.91	0.95 – 0.98	0.74 – 0.81
Dominance index range (D)	0.44 – 0.55	0.51 – 0.53	0.46 – 0.50

190. **Fish.** Six species of fish were found in Merdada lake and Cebong lake during the biodiversity study. All of these fishes are categorized as introduced since none is local to the Dieng Plateau area. None of these fishes are classified as protected species under prevailing Indonesian laws and regulations related to flora and fauna conservation. However, three fish species are given the IUCN status. The fish species identified in the mentioned lakes at the time of the biodiversity study is presented in Table 4.20.

191. Surface freshwater in the area is limited, largely restricted to a few streams and lakes which are heavily used for agricultural irrigation. There is no information available to assess whether these could still represent Natural Habitat but, judging by the amount of current water use, fishing and pollution, it seems likely that most freshwater in the area represents heavily altered Modified Habitat.

Table 4.20: Fish Identified

No.	English Name (Local Name)	Scientific Name	IUCN Status
1	Mozambique Tilapia (Mujair)	<i>Oreochromis mossambicus</i>	-
2	Nile Tilapia (Nila)	<i>Oreochromis niloticus</i>	LC
3	Catfish (Lele)	<i>Clarias gariepinus</i>	LC
4	Common Carp (Ikan Mas)	<i>Cyprinus carpio</i>	VU
5	Guppy (Cethul)	<i>Poecilia reticulata</i>	-
6	Tambaqui (Bawal)	<i>Colossoma macropomum</i>	-

Notes: IUCN Status: LC: Least Concern; VU: Vulnerable;

4.3.4 Critical Habitat Assessment

192. **Priority Biodiversity.** The Dieng project area including its landscape are located in a largely agricultural area comprising Modified Habitat, within a broader landscape which has an extensive tract of forested Natural Habitat (the Dieng Mountains). A Critical Habitat Assessment (CHA) identified that the project area is likely or actual Critical Habitat based on one or more of the following criteria:

- Criteria 1: Critically Endangered (CR) and/or Endangered (EN) species;
- Criteria 2: Endemic or restricted-range species;
- Criteria 3: Migratory or congregatory species;
- Criteria 4: Highly threatened and/or unique ecosystems;
- Criteria 5: Areas having biodiversity of significant social, economic, or cultural importance to local communities (including ecosystem services); and

- Criteria 6: Legally protected areas and international recognized areas.

193. Priority biodiversity of Critical Habitat Assessment identified that the Dieng landscape to be likely or actual Critical Habitat that qualifies for the Criteria 1, 2, and 6 as described in Table 4.21. One globally Critically Endangered and two Endangered primates (Javan Slow Loris, Javan Surili and Silvery Gibbon); the Critically Endangered Javan Leopard; one Critically Endangered and Two Endangered bird (Javan Green Magpie and Javan Hawk-eagle); three migratory birds of prey (Oriental Honey-buzzard, Chinese Sparrow hawk and Japanese Sparrow hawk); a restricted-range freshwater snail (*Gyraulus terraesacrae*); and the *Pengunungan Dieng* as Important Bird Area (IBA).

Table 4.21: Critical Habitat Criteria and Justification Applicable for Dieng

Priority Biodiversity Items	Species / Area	Critical Habitat Criterion qualified						Justification	Present in Project impact area?
		1	2	3	4	5	6		
Mammal	Javan Slow Loris (<i>Nycticebus javanicus</i>)	X						On a precautionary basis, based on its distribution, the AoA may well support more than 0.5% and five pairs of this globally Critically Endangered primate.	No
Mammal	Javan Surili (<i>Presbytis comate</i>)	X						AoA is likely to support more than 0.5% and five pairs of this globally Endangered primate.	No
Mammal	Silvery Gibbon (<i>Hylobates moloch</i>)	X						AoA supports more than 0.5% and five pairs of this globally Endangered primate.	No
Mammal	Javan Leopard (<i>Panthera pardus melas</i>)	?						Possible, though unlikely, that the AoA supports more than 0.5% and five pairs of this globally Critically Endangered subspecies, but listed here on a precautionary basis owing to its perilous status and public profile.	Possibly
Bird	Javan Hawk-eagle (<i>Nisaetus bartelsi</i>)	X						The AoA quite likely supports more than 0.5% and five pairs of this globally Endangered species.	Unlikely
Bird	Oriental Honey-buzzard (<i>Pernis ptilorhynchus</i>)			?				On a precautionary basis, given information from the north of the AoA, it is assumed that more than 1% of the global population passes through the Dieng Mountains AoA and that it regularly flies low and/or roosts in the Project area.	Yes
Bird	Chinese Sparrowhawk (<i>Accipiter soloensis</i>)			?				On a precautionary basis, given information from the north of the AoA, it is assumed that more than 1% of the global population passes through the Dieng Mountains AoA and that it regularly flies low and/or roosts in the Project area.	Yes
Bird	Japanese Sparrowhawk (<i>Accipiter gularis</i>)			?				On a precautionary basis, given information from the north of the AoA, it is assumed that more than 1% of the global population passes through the Dieng Mountains AoA and that it regularly flies low and/or roosts in the Project area.	Yes
Bird	Javan Green Magpie (<i>Cissa thalassina</i>)	?						Possible, albeit unlikely, that the AoA supports more than 0.5% and five pairs of this globally Critically Endangered species, but listed here on a precautionary basis.	No

Priority Biodiversity Items	Species / Area	Critical Habitat Criterion qualified						Justification	Present in Project impact area?
		1	2	3	4	5	6		
Freshwater snail	<i>Gyraulus terraesacrae</i>		X					The only known location for this species is on the Dieng Plateau.	Possibly
Internationally recognized area	<i>Pegunungan Dieng</i> Important Bird Area						X	Area of high biodiversity value, internationally recognized as an Important Bird Area.	Yes

194. The internationally recognized Dieng Mountains (*Pegunungan Dieng*) IBA (also *de facto* a Key Biodiversity Area) is overlapped by the northern part of the Project, including Well pads 10 and 30. This IBA was identified on the basis of its importance for Javan Hawk-Eagle and migratory birds of prey. The boundaries of this IBA appear to be imprecisely defined in relation to any physical or biological features, so not too much weight should be given to the boundaries of the area, which are likely generalized, rather to the distributions of the species for which it was identified.

195. Dieng Mountains have been identified as an IBA, primarily owing to globally significant concentrations of migratory birds of prey. Nijman (2001, 2004) studied these concentrations during autumn migration on the northern side of the Dieng Mountains, estimating that around 23,000 Chinese Sparrow hawk pass through the area annually. The global population of this species is estimated at 100,000 - 499,999 mature individuals (BirdLife International 2016b). Using the same adjustment factor applied by Sercx *et al.* (2018), the number of mature individuals passing through the Dieng Mountains is estimated to be 15,410, i.e., 3 - 15% of the global population. It has been hypothesized that the southern side of the Dieng Mountains (in the vicinity of the Project) is more important on spring migration, when few migrating birds of prey are seen on the northern side (V. Nijman, Oxford Brookes University, pers. comm. 2019).

196. **Habitat types.** Figure 4.14 summarizes the location of Natural and Modified Habitat within the Dieng's Project Area of Analysis (AoA). The AoA mostly comprises Natural Habitat (forest), although the immediate Project area itself comprises Modified Habitat (particularly dry-land agriculture). Data are sufficiently sparse on the distribution of Critical Habitat-qualifying species in the Dieng Mountains to preclude detailed mapping of terrestrial Critical Habitat. The Area of Analysis qualifies as Critical Habitat, owing to the presence of several Critical Habitat-qualifying species at globally significant levels and the presence of nationally-protected and internationally-recognized areas.

197. **Legally protected areas and internationally recognized areas.** There are two protected sites in the vicinity of the Project: Telogo Sumurup Nature Reserve and the Telogo Warno Pengilon Nature Recreation Park (Figure 4.14). Telogo Sumurup is closely bounded on three sides by the existing Dieng geothermal plant, and is a relatively small (20 ha) IUCN Category III protected area, focused upon a lake. Although classified as a nature reserve, this appears to have been gazetted more for its scenic value than for biodiversity, and is thus not considered to qualify the AoA as Critical Habitat under the Performance Standard 6 of the IFC (IFC 2019). Telogo Warno Pengilon, an IUCN Category V protected area also focused on some scenic lakes, lies just to the east of the Project.

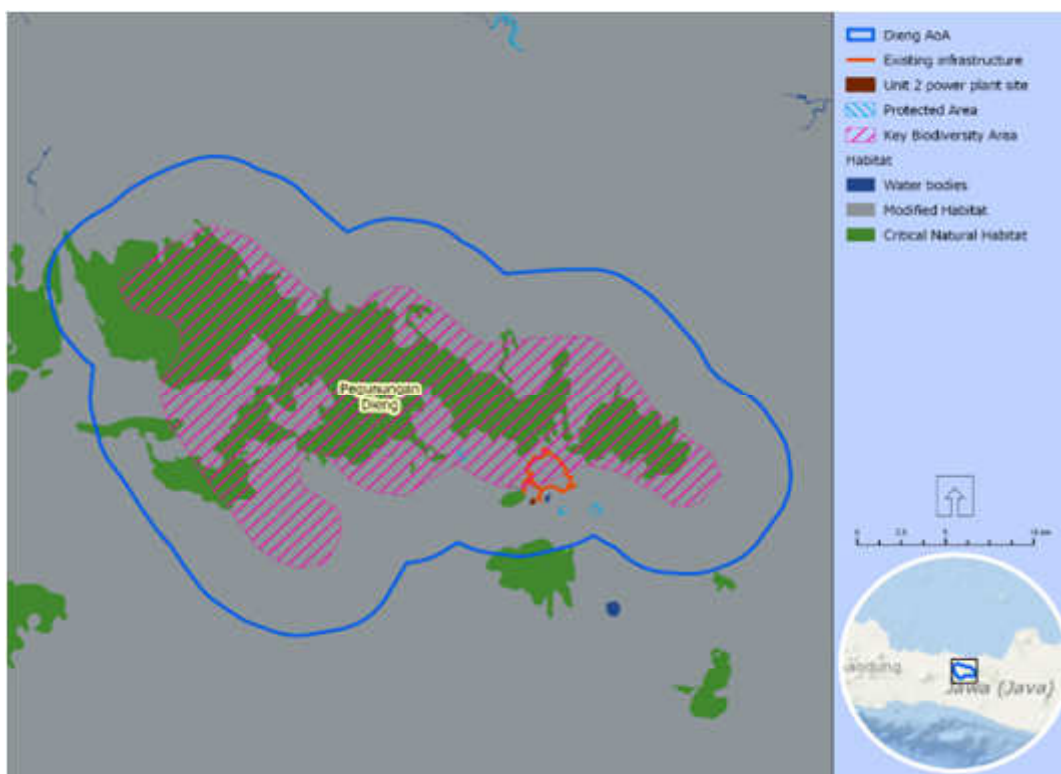


Figure 4.14: Area of Analysis of Dieng Project Area

4.4 Socio-economics and Land Use

198. **Overview.** In 2018, GDE conducted the socio-economics and stakeholder mapping and analysis associated with the Dieng geothermal power generation. This undertaking is in addition to the semi-annual environmental and social monitoring conducted to comply with the requirement of the government-approved ANDAL and RKL-RPL revision (2004). The following subsections describe the results of these undertakings at the villages (*desa*) of Karang Tengah, Kepakisan, Dieng Kulon, Bakal, Sikunang, and Pranten villages, which are within the proximity of the existing Dieng Unit 1 and proposed Dieng Unit 2 power plants including their support infrastructures. Other villages located within the wider project area include Pekasiran, Dieng, Sembungan, and Jojogan, and social monitoring at these villages are also conducted.

199. **Population.** The number of population and population density at the mentioned 10 villages (as of 2016) are presented in Table 4.22. Pekasiran has the largest number of population and area compared to others, but its population density is not the highest compared to the other nine villages. The sex ratio among male and female population at the 10 villages is reported to be relatively similar within a range of 0.97 – 1.10. Although the population density of these villages is relatively low, residential settlements, farmlands, tourism objects such as crater and small temples are within the proximity of the Dieng project area (i.e., existing Unit 1 and future Unit 2 including associated well pads, pipeline and gathering systems).

Table 4.22: Village Population and Density at Village Level

Village	Area (km ²)	Total Population (people)	Population density (people/km ²)
Wonosobo District, Batur Subdistrict			
Bakal	6.96	3,831	549.73
Karang Tengah	4.22	4,618	1,095.09
Kepakisan	12.12	2,836	233.91
Dieng Kulon	1.98	3,222	1,628.35
Pekasiran	8.63	5,073	587.85
Banjarnegara District, Kejajar Subdistrict			
Sikunang	2.08	2,203	1,059.70
Dieng	2.82	2,117	750.71
Sembungan	2.65	1,267	478.11
Jojogan	1.26	1,399	1,110.32
Batang District, Bawang Subdistrict			
Praten	7.99	1,433	179.38

Source: Dieng Social Mapping and Social Engineering Report (PT Miranthi, 2018).

200. Within the context of District (*kabupaten*) as of 2016 (Table 4.23), the Banjarnegara District had the largest area and population compared to Wonosobo and Batang Districts. However, Batang Sub-district had the largest population density compared to other districts. Batang District experienced the highest population growth of close to 0.9% per annum. The highest unemployment rate was recorded at 4.56% in Batang District.

Table 4.23: Demographic Profile at District Level

Districts	Area (km ²)	Total population (people)	Population density (people/km ²)	Population Growth (%)	Unemployment Rate (%)
Banjarnegara	1,064.52	907,410	848	0.62	4.06
Wonosobo	984.68	780,667	793	0.50	4.47
Batang	788.6	749,720	951	0.89	4.56

201. **Community Livelihood.** As presented in Table 4.24 majority of the respondents at the 10 villages work as landowner and daily labor predominantly engaging in crop farming and plantation sectors. The next dominant employments are as government official, trader/businessman, housewife, employees working for the private sector. The remaining respondents working as teacher, professional, freelancer, and motorcycle taxi (*ojek*).

Table 4.24: Employment of the Respondents

Village	Employment Type														
	Landowner	Daily farmer/ labor	Government officer	Army/Police Member	Trader	Civil servant	Businessman	Teacher	Worker in private	Freelancer	Professionals	Motorcycle taxi (ojek)	Housewife	Student	Others
Bakal	47%	17%	11%	2%	6%	-	2%	-	-	-	-	-	13%	2%	-
Karangtengah	29%	22%	3%	2%	13%	2%	2%	2%	7%	-	-	2%	16%	-	-
Kepakisan	14%	40%	-	-	13%	2%	2%	-	9%	-	-	2%	16%	-	2%
Dieng Kulon	28%	6%	5%	-	24%	2%	5%	9%	7%	6%	-	-	-	2%	6%
Pekasiran	18%	26%	2%	-	18%	2%	4%	2%	4%	4%	-	6%	4%	6%	4%
Sikunang	45%	21%	2%	-	10%	4%	2%	-	2%	-	-	-	14%	-	-
Dieng	19%	4%	-	-	15%	2%	29%	-	15%	4%	6%	2%	2%	2%	-
Sembungan	50%	10%	2%	-	6%	4%	6%	2%	2%	6%	-	-	12%	-	-
Jojogan	50%	23%	-	2%	6%	2%	7%	-	4%	-	-	2%	4%	-	-
Pranten	70%	14%	2%	-	2%	-	4%	-	2%	2%	-	-	4%	-	-

Source: Dieng Social Mapping and Social Engineering Report (PT Miranthi, 2018).

202. **Income Level.** Figure 4.15 shows the profile of the respondents based on their income level. Majority of the respondents at 10 villages earn up IDR 1.5million/month (or \$107/month, at the exchange rate of \$1 is equal to IDR 14,000). Those earning in a range of IDR 1.5 – 3.5 million/month (or \$107 – \$250/month) are generally up to 35% of the respondents across all villages. Approximately less than 15% of the respondents across all villages earn more than IDR 3.5 million/month (\$250/month). This level of income indicates a similar trend across 10 villages, corresponding to the fact that most of the respondents are landowner and daily farmer/labor, while the remaining respondents are distributed in numerous employment sectors.

203. The survey at the ten villages mentioned indicate that most of the respondents prefer to continue working as labor in the farming and/or plantation sectors, particularly potato and vegetables as they have been relying on these sectors as their primarily livelihood for indefinite period. Further, they still think that Dieng area is fertile to support productive farming and plantation sectors although this situation may not be too promising as it is used to be.

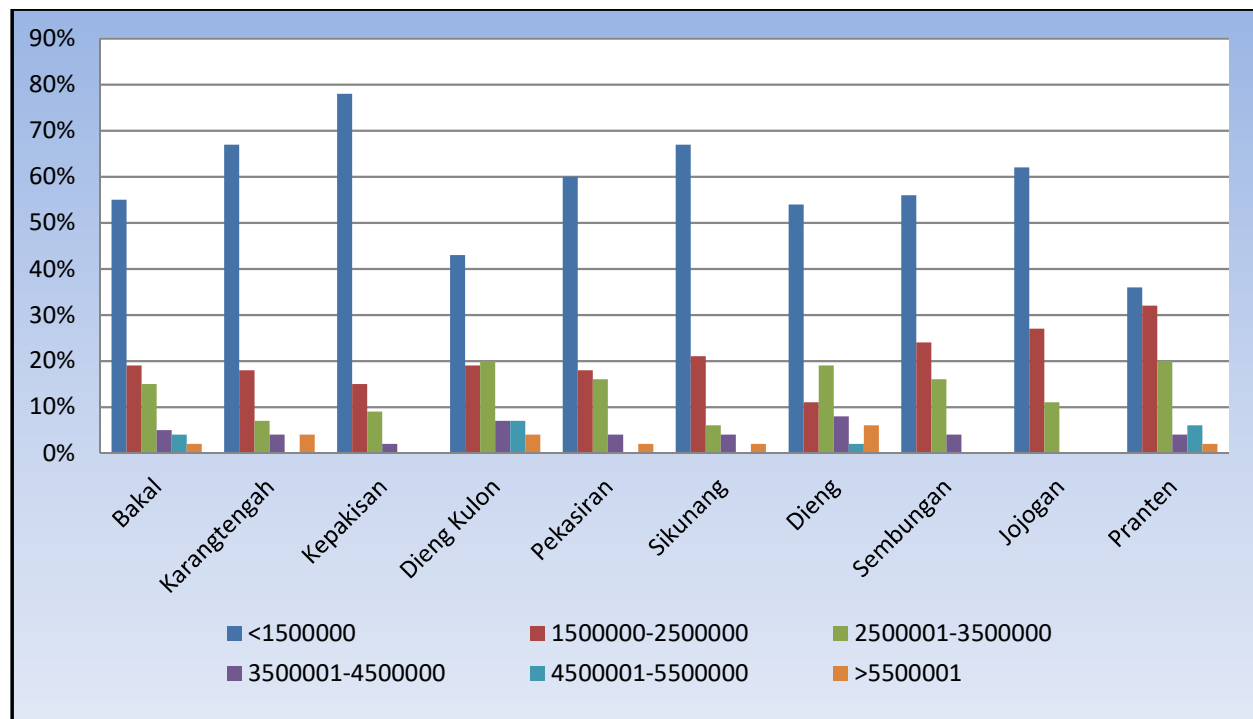


Figure 4.15: Income Level of the Respondents

204. **Education Level.** Limited enrolment in secondary level education, i.e., senior high school (SMA) and vocational school (SMK) as well as tertiary level education i.e., diploma and university (S1) are apparent within majority of the respondents across the 10 villages. Majority of the respondents are graduating or enrolled in primary school (SD) and junior high school (SMP) levels. This relatively low education level and limited access to funding remain the bottleneck of the respondent to improve their welfare through establishment of new businesses, supplier of goods and services or working as professional in the formal employment sectors.

205. Alternative livelihoods such as the development of carica and herbs as processed agricultural products, establishment of homestays and provision of tour guides to support tourism activities are reportedly emerging in Dieng area. However, some respondents remain reluctant to expand or switch their livelihoods beyond renting or growing the land with potatoes and vegetables as they feel that the economic power of potatoes would remain promising in the near future.

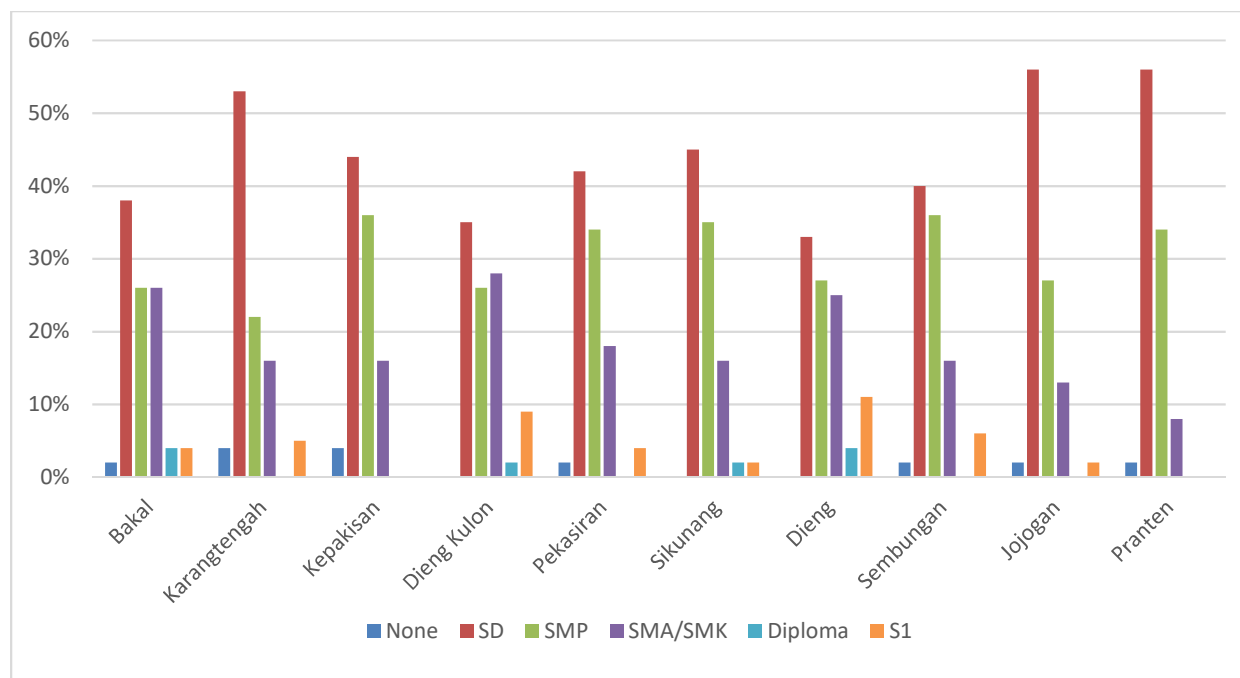


Figure 4.16: Education Profile of the Respondents

206. **Water Supply and Sanitation.** Clean waters from shallow wells, existing ponds as such as Merdada and Cebong, and spring waters are key sources for community household and toileting facilities. For watering their crops and plants, the landowner and farmer tap the water from the spring and lake and then channeled it using small diameter PVC pipeline to their farmlands and garden. There are issues related to the water source that it becomes saline and scarce, primarily during the dry season.

207. In terms of sanitation they usually use communal facilities for bathing, washing and toileting (public latrines) or have a toilet in their home connected to septic tank system.

208. **Solid Waste Management.** Storage, handling, and disposal facilities for solid waste are lacking in Dieng Plateau area. The community inform that household wastes generated by the residents are barely collected and disposed by the local governments. Further, it is reported that no dedicated waste disposal site or waste landfill is available in Dieng area, either in the administrative area of Bojonegoro or Wonosobo District. However, initiatives to improve waste management practices are started at Bakal village by establishing a garbage bank and providing trash bins.

209. **Infrastructure and Telecommunication.** Access roads to/from Dieng Plateau including at the villages in the region are primarily made of asphalt pavement and generally maintained in good condition. The width of the road in this area including the right-of-way (ROW) is approximately no more than 8 m – 10-m width. Access to cellular phone network is widely available in the area. Each village has its office and hall. There are about 33 mosques and 106 prayer rooms for Muslim (*mushola*) identified in the 10 villages mentioned earlier.

210. **Electricity.** The area of Dieng plateau is connected with electricity grid, thus most of the houses have been connected with power distribution networks. Some low-income households

have reportedly been connected to the power grid and installation of electric meter at their home through GDE's supports.

211. The 2009 – 2029 Spatial Plan of Central Java Province. It is promulgated by the Provincial Regulation of Central Java (*Peraturan Daerah*) No. 6/2010 (dated 21 July 2016). Article 81 paragraph (a) of the mentioned regulation stipulates that, among other, the Dieng geothermal power development area is designated in Banjarnegara District and Wonosobo District. Further, the area of Dieng plateau is designated for protection forest, production forest, nature reserve, plantation, and tourism. Figure 4.17 presents the spatial plan in part of the mentioned districts in relation to the GDE project site.

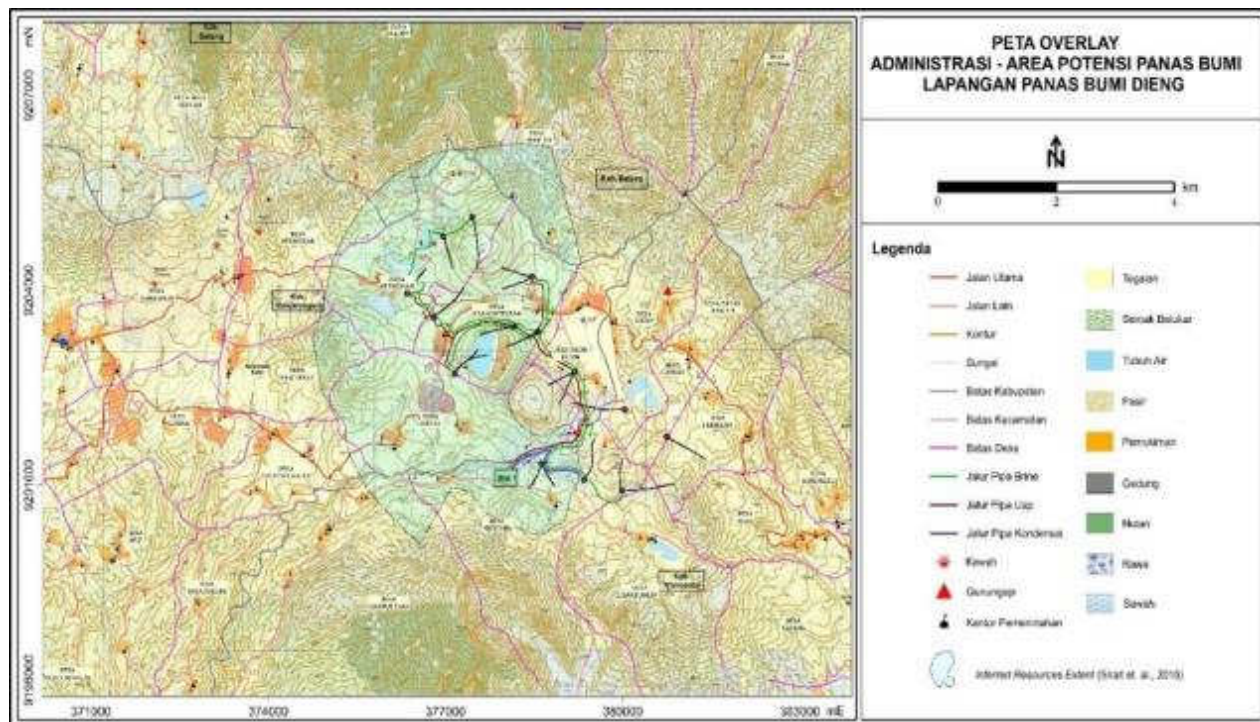
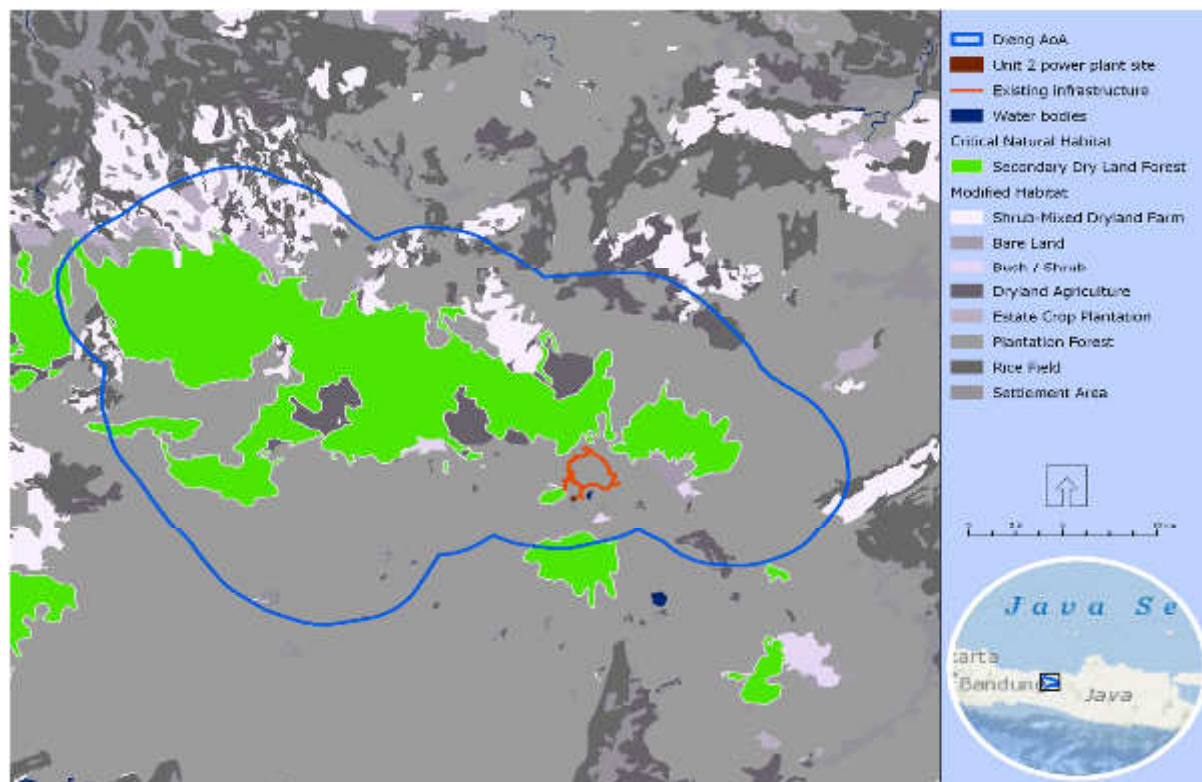


Figure 4.17: Geothermal Potential Area Overlaid with Land Use

212. Existing Land Use. The existing land use based on the MoEF classification (2017) within the Dieng Plateau and in relation with GDE project site is shown in Figure 4.18. This figure indicates areas likely to represent Natural Habitat (in green shade) and Modified Habitat (in grey shades). Secondary dry land forest and dryland agricultural practice appear dominating in the Dieng's area of analysis (AoA) which is established for the purpose of critical habitat assessment. Distribution of modified habitat, including shrub-mixed dryland farm, estate crop plantation, and settlement areas is quite widespread within the AoA.



Source: MoEF land use classification (2017); Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

Figure 4.18: Existing Land Uses and Land Cover within Dieng Plateau

213. Physical Cultural Resources. The Dieng temple compound is located at Dieng Plateau on an elevation of 2093-masl. This Hindu temple was constructed from the 8th century to 9th century to worship the God of Siva and reportedly one of the oldest Hindu temples in Java. The Dieng temple was rediscovered in 1814, when an English soldier was on vacation to Dieng and saw a cluster of temples submerged in lake. In 1956, Van Kinsbergen organized an effort to drain the lake in which the temples compound was situated. The Dutch government continued the work in 1864, while Van Kinsbergen documented the temples and took the picture of them. The Dieng temple compounds occupies an area of approximately 18 hectares and consists of the following temples, i.e., Arjuna, Gatutkaca, Dwarawati, Setyaki, Bima, and Dharmasala (Figure 4.19).



Source: <https://situsbudaya.id/544-2/>

Figure 4.19: Candi Dieng Compound

4.5 Community Health

214. **Public Health Profile.** Types and number of medical cases recorded for Batang, Banjarnegara and Wonosobo districts that overlap with GDE Dieng project areas are presented in Table 4.25. These data indicate that the total number of nine medical cases recorded in 2018 was around 49,000 for Banjarnegara, 23,370 for Wonosobo, and 10,580 for Batang.

215. The 2018 data indicates that the top three medical cases in Banjarnegara were malaria (suspect), diarrhea, and pneumonia, contributing to around 43%, 40%, and 12% of total cases treated in the mentioned district. In Wonosobo district, most medical cases are diarrhea contributing to almost 68%, followed by malaria (suspect) of up to 15% and pneumonia of up to 10% of the total cases treated in that year. The Batang district (covers only Pranten village within the proximity of GDE Dieng operation) recorded diarrhea as the highest number of medical cases, contributing to almost 72% of the total cases, followed by tuberculosis and pneumonia, contributing close to 10% and 8% respectively of the total cases.

216. The villages in Dieng Mountains are located in high altitude and generally have very cold temperature that makes malaria parasite and its mosquito carrier are difficult to live, and the possibility of Malaria development in this area would be low. However, the data on malaria (suspect) cases broken down by each sub-district in Banjarnegara and Wonosobo District is not available.

217. Diarrhea, pneumonia, and tuberculosis were among the top three of medical cases treated in all three districts. These events indicate that sanitation and personal hygiene are key community health issues in the districts of concerned.

218. HIV/AIDS and sexually transmitted diseases contributed to around 1.7% in Banjarnegara, 4.1% in Wonosobo, and 11% in Batang of the total medical cases treated in each district.

Table 4.25: Medical Cases Treated at District Level (2018)

Medical Case	Banjarnegara District		Wonosobo District		Batang District	
	Number of cases	Percentage of total cases (%)	Number of cases	Percentage of total cases (%)	Number of patients	Percentage of total cases (%)
Malaria (suspect)	21,118	43.1%	3,502	14.99%	3	0.03%
Tuberculosis	1,403	2.9%	956	4.09%	999	9.45%
Pneumonia	5,885	12.0%	2,211	9.46%	753	7.12%
Leprosy	3	0.1%	20	0.09%	51	0.48%
Diarrhea	19,703	40.2%	15,696	67.18%	7,548	71.39%
Dengue fever	80	0.2%	41	0.18%	68	0.64%
HIV	224	0.56%	348	1.49%	718	6.79%
AIDS	187	0.4%	202	0.86%	227	2.15%
Sexually transmitted diseases (STD)	347	0.7%	388	1.66%	206	1.95%
Total cases	48,977	-	23,365	-	10,573	-
Total population	918,219	-	787,384	-	762,377	-

Sources: <https://jateng.bps.go.id/dynamictable/2019/09/20/501/jumlah-kasus-penyakit-menurut-jenis-penyakit-menurut-kabupaten-kota-di-provinsi-jawa-tengah-2018.html> (accessed 5 Oct 2019).

4.6 Occupational Health and Safety

219. **Accreditation Granted.** GDE Dieng has been implementing an integrated environmental, and occupational health and safety (EHS) management system following the requirements of ISO 14001:2015 on Environmental Management System and the Government Regulation No. 50/2012 on Implementation of Occupational Health and Safety Management System. Related EHS Policy, manual, procedures, and forms have also been established for effective implementation based on the following documentation and record hierarchy: Level 1 (Manual, Guidelines, Standard, Policy); Level 2 (Standard Operating Procedures, job descriptions); Level 3 (Work Instruction, Letter); and Level 4 (Form, notes).

220. The ISO 14001:2015 certification has been granted for GDE Dieng for the power plant and steam field operations in August 2017 and the certification is valid until August 2020 (Figure 4.20). In addition, GDE Dieng has been certified for its occupational health and safety management system by the Ministry of Employment based on the Decree No. 201/2017 (dated 14 July 2017) as shown in Figure 4.21.

221. **EHS Procedures.** GDE Dieng has developed a suite of standard operating procedures (SOPs) to facilitate implementation of their EHS Management System. These SOPs (Table 4.26) are developed for 53 aspects representing the “plan-do-check-act” and management review principles required by ISO 14001:2015. A full description of GDE’s Environmental Management System including the facility’s emergency preparedness and response procedure is presented in Appendix 7.



Figure 4.20: ISO 14001:2015 Certificate of GDE Dieng



Figure 4.21: Occupational Health & Safety Management System Certificate of GDE Dieng

Table 4.26: Standard Operating Procedures of GDE Dieng

Document No.	SOP Title / Aspect
MN/001	Manual of EHS management system
SOP-001-R1	Document and record control (documented information)
SOP-002-R1	Risk assessment
SOP-003-R1	Obligation and compliance of health & safety laws and other requirements
SOP-004-R1	Non-compliances and corrective actions
SOP-005-R1	EHS internal audit
SOP-006-R1	Communication, consultation, and participation
SOP-007-R1	Management review
SOP-008-R1	Monitoring and measurement
SOP-009-R1	Management of change
SOP-010-R1	Maintenance of production facilities
SOP-011-R1	Reporting and investigation of accidents
SOP-012-R1	Personal protective equipment
SOP-013-R1	EHS inspection
SOP-014-R1	Emergency preparedness and response
SOP-015-R1	Preparedness and response to earthquake event
SOP-016-R1	Blow out prevention and management
SOP-017-R1	Preparedness and response to toxic gas releases
SOP-018-R1	Preparedness and response to landslide events
SOP-019-R1	Preparedness and response to flooding events
SOP-020-R1	Preparedness and response to fire events
SOP-021-R1	Wildlife encounter
SOP-022-R1	Handling of broken pipelines
SOP-023-R1	Requirements for driving company's vehicles
SOP-024-R1	Parking the car
SOP-025-R1	Chemical handling
SOP-026-R1	Welding works
SOP-027-R1	Working with high voltage electricity
SOP-028-R1	Working at height
SOP-029-R1	Working with high-temperature fluids
SOP-030-R1	Confined space entry
SOP-031-R1	Lifting
SOP-032-R1	Working in confined space
SOP-033-R1	Site visit
SOP-034-R1	Safe work permit
SOP-035-R1	Excavation works
SOP-036-R1	Objectives, targets, and programs
SOP-037-R1	Management of hazardous and toxic wastes ("B3 wastes")
SOP-038-R1	Management of non-hazardous and non-toxic wastes
SOP-039-R1	Handling of farmer claims
SOP-040-R1	Management of spills and leaks of B3 wastes
SOP-041-R1	Management of electricity, water and other resource uses
SOP-042-R1	Job safety analysis
SOP-043-R1	Certification of production equipment
SOP-044-R1	Calibration of equipment
SOP-045-R1	Surveillance of occupational health and hygiene
SOP-046-R1	Restriction of access to high-risk areas
SOP-047-R1	Lock Out Tag out
SOP-048-R1	First aid

Document No.	SOP Title / Aspect
SOP-049-R1	Health and safety signage
SOP-050-R1	Handling of security disorder
SOP-051-R1	Contactor safety management system
SOP-052-R0	Safety induction
SOP-053-R0	Risk and hazard observation

222. **Staffing.** The current EHS Division of GDE Dieng comprises one EHS manager supported by one occupational health & safety supervisor, one occupational health & safety superintendent and environmental monitoring staff. They report to the General Manager of Patuha, as the top management representative accountable for EHS implementation on day-to-day basis. The EHS Division of Dieng also coordinates with the EHS Assistant Manager at the GDE Headquarters in Jakarta on EHS matters related to corporate affairs. As of 2018, GDE Dieng employed up to a total of 312 personnel, comprising 99 staff and 214 contractors (including some internship personnel).

223. **EHS Statistics.** GDE Dieng recorded no accidents or near miss events in 2018 for a total of almost 572,650 hours worked for the year. Correspondingly the total recordable incident rate and severity rate for the year was also zero.

4.7 Corporate Social Responsibility

224. GDE has been conducting its Corporate Social Responsibility (CSR) activities as integral part of its geothermal power generation. These activities are intended to continue developing a harmonious and synergistic relationships between the Company and the communities within the villages and sub-villages within the proximity of GDE project areas. The CSR activities conducted in 2018 are presented in Table 4.27.

Table 4.27: Corporate Social Responsibility (CSR) Activities in 2018

Activities	Village/Sub-village
Provision of primary household subsistence at low cost leading to Eid Mubarak festive, such as rice, sugar, cooking oil, and egg (known as <i>Sembilan bahan kebutuhan pokok</i> or “sembako”), and building materials. Financial supports for medication and other incidental community's occasions.	Siterus
Provision of “sembako” at low cost leading to Eid Mubarak festive and donation of kettle (e.g. cow)	Dieng Wetan
Repair of the village's entry gate and the roof of some houses, and some financial supports for religious activities.	Dieng Kulon
Construction of street lighting, pavement for the road, and repair for the roof of some houses.	Pawuhan
Provision of “sembako” at low cost leading to Eid Mubarak festive, PVC pipeline and assistance for some house reparation.	Simpangan

Activities	Village/Sub-village
Provision of "sembako" at low cost leading to Eid Mubarak festive, PVC pipeline, and carpet for the mosque.	Kepakisan
Provision of "sembako" at low cost leading to Eid Mubarak festive, replacement of the roof, and supports for some house repairs.	Karang Tengah
Provision of "sembako" at low cost leading to Eid Mubarak festive, supports for the construction of infrastructure, and donation for the orphanage.	Karang Sari
Provision of construction materials including cement, street lighting, and mass circumcision surgery as religious activity.	Sikunang
Provision of donation to the mosque, railing and stairs (made of steel), construction of the village's entry gate and access road to tourism object, donation to orphanage, and lending of small, mobile generator for certain community occasions.	Sembungan

5 ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

5.1 Scoping of Environmental Risks and Impacts

225. The scope of the assessment is the project area of influence as described in Section 4 as well as transportation routes to/from the project location. The baseline environmental and social setting (Section 4) described the area of influence, including receptors.

226. At project inception stage, the project was screened against various aspects of the following parameters, for the well drilling, construction, operation and decommissioning stage:

- Natural resources (air, water, land, biodiversity)
- Waste (hazardous and non-hazardous)
- Natural hazards (landsides, floods)
- Noise
- Occupational and community safety
- Community concerns

227. **Assessment of the level of significance** requires consideration of the likelihood and magnitude of the environmental effect; its geographical scale and duration in relation to the sensitivity of the key receptors and resources are also considered. Criteria for assessing the significance of impacts stem from the following key elements:

- The magnitude (including nature, scale and duration) of the change to the natural environment (for example, loss or damage to habitats or an increase in noise), which is expressed in quantitative terms wherever practicable.
- The nature of the impact receptor, which may be physical, biological, or human. Where the receptor is physical (for example a water body) its quality, sensitivity to change and importance are considered. Where the receptor is biological, its importance (for example its local, regional, national or international importance) and its sensitivity to impact are considered. For a human receptor, the sensitivity of the community or wider societal group is considered along with its ability to adapt to and manage the effects of the impact.
- The likelihood (probability) that the identified impact will occur is estimated based upon experience and/or evidence that such an outcome has previously occurred.
- The significance of impacts is then devised from a combination of the sensitivity of the receptor, the magnitude of impact and the likelihood of occurrence.

228. In the IEE screening and scoping, the following impacts were identified, based on the ANDAL, site investigations and further assessment undertaken in this IEE. The identified impacts are described and analyzed in the following sections.

Table 5.1: Screening and scoping of environmental impacts

Environmental and Social Impacts	Activity Stage			
	Pre-construction (land preparation, mobilization, minor civil works, well drilling)	Construction (Power Plant construction, SAGS construction)	Operations	Decom-missioning
Physical-Chemical				
H ₂ S Emissions	-		-	
GHG			-	
Dust	-	-		-
Noise	-	-	-	-
Erosion, Water quality	-	-		-
Surface water usage	-		-	
Waste/Sludge	-	-	-	-
Biodiversity				
Fauna	-		-	
Flora	-		-	
Invasive Species	-			
Social and Cultural				
Employment Opportunities	+	+	+	+
Cultural heritage	-	-		
Land Acquisition	-	-		
Community Concerns	+/-	+/-	+/-	
Community Safety	-	-	-	-
Traffic and Transportation	-	-		
Work force safety	-	-	-	-

Note:

- Negative Impact

+ Positive Impact

229. The **impact assessment** is divided into two parts: (i) the potential environmental impacts and mitigation measures, and (ii) safety risk assessment of the existing Dieng Unit 1²³ and the proposed Dieng Unit 2.

230. Environmental monitoring will be conducted regularly from pre-construction, construction, and operation for ambient air quality, noise, water quality, and biological environment as required by GOI and ADB. A 3rd party environmental entity accredited by the MOEF will be engaged by GDE to do the work. Results of the environmental monitoring will be submitted to MOEF and the ADB.

²³ For those components of Unit 1 that classify as existing and/or associated facilities, primarily the existing well pads where new wells will be installed for Unit 2.

5.2 Project Phases

231. The assessment of potential environmental impacts cover the entire project cycle: (i) pre-construction phase, (ii) construction phase, (iii) operation phase, and (iv) decommissioning. The pre-construction phase includes the FEED and detailed engineering design, site preparation including minor civil works including road and water supply construction, removal of existing structures at site of Unit 2 and mobilization of equipment. The construction phase covers and drilling of geothermal wells (well development) and construction of the steam above ground gathering system (SAGS) and the power plant. The operation phase refers to operation of power plant and SAGS.

5.2.1 Front end engineering design (FEED)/Detailed engineering design

232. This phase will confirm the specifications and requirements where one of the basis is the Feasibility Study Update August 2019. The activities aim to develop an approved for construction design including tender documents.

233. The power plant, equipment and pipe works will be subject to wind and seismically-induced forces and, thus will be designed based on the applicable technical regulations and standards. Some relevant design criteria include the following:

234. *Seismic design* The basis of seismic design of the power station plant and facilities will be the current Indonesian standard for seismic resistant design; “*Standar Perencanaan Ketahanan Gempa Untuk Struktur Bangunan Gedung*”, SNI-1726-2002. The EPC contractor in charge of powerplant and SAGS DED will be required to conduct a *seismic hazard study* to demonstrate that the structural design of the power plant and SAGS is seismically safe for anticipated seismic risks. The structural design will be checked by a suitably qualified and experienced 3rd party structural engineer who is independent of GDE, the designer and the contractor.

235. The seismic hazards maps in SNI-1726-2002 were prepared before 2002, but in 2010 were upgraded by the Indonesia Ministry of Public Works. These upgraded seismic hazards maps cover both 10% probability of exceedance and 2% probability of exceedance in 50 years, the typical design life of major structures. The results are based on a more accurate seismic hazards model and consideration of post 2002 large magnitude earthquakes in some regions of Indonesia.

236. In the FEED stage, a flood risk assessment and storm drainage analysis will need to be carried out by the Project Management Consultant (PMC). The design wind speed for buildings and structures in Indonesia is usually in accordance with the American Society of Civil Engineers (ASCE) standard and the relevant Indonesian standard whichever is more severe and is not less than 33.3 m/s. The calculation of wind load is performed in accordance with the formulation given in standard ANSI/ASCE 7-95.

237. For well drilling, some relevant standards will be referred to such as the New Zealand Standard Code of Practice for deep geothermal wells (NZS 2403: 2015), and the National Association of Corrosion Engineers (NACE) in NACE MR01753 and ISO 15156. NACE and ISO give requirements and recommendations for the selection and qualification of carbon and low-alloy steels, corrosion-resistant alloys, and other alloys for service in equipment used in oil and natural gas production and natural gas treatment plants, both H₂S-containing environments,

whose failure could pose a risk to the health and safety of the public and personnel or to the equipment itself.

238. *Powerplant Design* To consider environmental impacts during operation of Unit 2, the EPC contractor will be required, as part of the DED, to conduct (i) detailed air dispersion modeling to confirm compliance with ambient H₂S level (28µg/m³, 24-hr averaging time) and emission level (30 mg/Nm³); (ii) detailed noise modeling to demonstrate compliance to the values set by the IFC-WB EHS General Guidelines 2007 (i.e., 55dB, 45dB, 3dB increment); and (iii) an explosion risk assessment for the organic fluid storage tank at Unit 2. Unit 2 will use butane (C₄H₁₀)²⁴ and isopentane (C₅H₁₂)²⁵ as the working fluid for the bottoming organic Rankine cycle (ORC). Given the chemical nature of these substances, design of storage tanks and handling will strictly comply with international industry standards and codes. The results from these studies will be disseminated to the potentially affected people. The final design will also integrate aesthetic and landscape architecture elements as in “design with nature” to blend with the existing landscape.

239. At this stage, the PMU will establish the grievance redress mechanism (GRM), the information center, and produce the interactive 3-D models, produce leaflets, etc., on project aspects (FAQ, IEE/EMP, GRM). PMU will also establish and maintain project website and/or social media presence.

5.2.2 Demolition of Existing Structures at the Project Site

240. There are existing structures in the proposed power plant site that require demolition. Works involved in demolition will potentially increase dust and noise levels, generate demolition wastes, and pose occupational and community safety risks.

241. Prior to demolition, a rapid assessment study will be done by the PMC (or through a 3rd party qualified expert if expertise is not available within the PMC) to determine the presence of asbestos-containing materials (ACMs). The assessment will be one of the basis for the preparation of a demolition plan to be approved by PMC/GDE and the relevant authority. Removal of hazardous wastes, if any, will comply with the requirements of the GOI, the IFC-WB EHS General Guidelines 2007, and WHO on waste management. GDE has HSE SOP-037-R1 on management of hazardous and toxic wastes (“B3 wastes”). This SOP has been accredited as in compliance with the requirements of ISO 14001 and OSHAS 18000.

242. Demolition will be done through tendering process. The bidding document will specify the regulatory requirements, permits, and the standards/codes relevant to demolition and disposal of material and debris, by which the contractor will be required to comply. Aside from this, the bidding documents will describe the measures required to ensure occupational, environmental and public safety risks are minimized. The contractor will be required to consult and/or announce to the settlements in Karang Tengah and Dieng Kulon about the schedule, activities, and the site-specific safety and work plans for the workforce, local communities, and the service vehicles.

²⁴ Butane is a colorless gas with a faint petroleum-like odor. For transportation it may be stench. It is shipped as a liquefied gas under its vapor pressure. Contact with the liquid can cause frostbite. It is easily ignited. Its vapors are heavier than air. Any leak can be either liquid or vapor. Under prolonged exposure to fire or intense heat the containers may rupture violently and rocket. It is used as a fuel, an aerosol propellant, in cigarette lighters, and to make other chemicals. <https://pubchem.ncbi.nlm.nih.gov/compound/Butane>.

²⁵ with nature” given the existing land use in Dieng. Watery colorless liquid with a gasoline-like odor. Floats on water. Flammable, irritating vapor is produced. <https://pubchem.ncbi.nlm.nih.gov/compound/Isopentane>.

243. Monitoring of ambient noise and air quality including measurements of vibration will be conducted by a 3rd party to be engaged by GDE during the demolition works. The contractor will comply with the requirements of the Ministry of Environment Regulation No. 18 of 2009 on Obtaining Permits for Storage, Treatment and Disposal of Hazardous Waste.

244. PMU will ensure compliance of the contractor to the provision of temporary sanitary facilities, safe drinking water, and use of personal protective equipment (PPE) and safety gears. Unauthorized access will not be allowed. GDE will designate security personnel to monitor access to the site. At present, the project site of about 6 ha is planted to cash crops like potato, cabbage, carrots, etc. The area is secured with metal fence but due to apparently lack of good maintenance, some parts are missing that unauthorized access cannot be entirely avoided.

5.2.3 Construction Phase

245. Construction works will involve recruitment of workers and staff, mobilization of equipment and machineries; earth moving, land clearing; well drilling and venting; civil, mechanical, electrical, structural and other engineering works necessary for SAGS, power plant and data control center; the underground cable transmission lines; and the waste management infrastructure and support facilities. The main sources of impacts of construction works are as follows:

- five well pads (i.e., Pad #9, Loc I, Pad #7, Loc Q/Pad #31, Loc O for 5 production wells and 5 reinjection wells);
- about 1.8 km of access roads;
- approx. 9.13 km of pipelines (SAGS) from the production wells to Unit 2;
- about 5.05 km of reinjection pipelines; and
- the power plant facilities.

246. Well drilling will be the most impactful activity during construction. Dieng is a liquid dominated geothermal field which host relatively deep and high temperature reservoir. The main reservoir temperature ranges from 300°C-330°C and located below 1,500 meters depth down to 3,000 meters depth. Drilling of five new production wells will be required to sustain the operation of Unit 2. During this phase, several wells will be drilled from a single pad, and this will minimize surface clearings. Wells will be drilled in series (as opposed to in parallel) to minimize cumulative temporary impacts on noise and surface water resources.

247. A rotary well drilling rig will be used to drill each well directionally with a depth of up to 3,000 m. Directional drilling will be employed. The geothermal-fluid from production wells will be separated into steam and brine. Main concerns in well drilling activities are generation and handling of drilling waste, water requirements, noise, ambient releases of H₂S, loss of vegetation, and potential water and soil and contamination in the event of sump or pond failure. However, the potential impacts of well drilling are confined and localized to the wellpad and surrounding areas.

248. Associated impacts during this phase are generally temporary, of short duration, localized and can be mitigated through the implementation of mitigation measures specified in the environmental management plan (EMP) and environmental monitoring plan (EMoP), and compliance by the Contractors to applicable regulations of GOI particular on occupational and environmental health and safety.

249. Mobilization and demobilization of construction vehicles, heavy equipment, and materials may result to increased road traffic/traffic congestion, road accidents, and road damages.

250. Prior to any construction works and drilling activities, the HSE and Safeguards Unit of Dieng Unit 2 Site Office along with representative from Jakarta Office HSE and Safeguards Unit will conduct briefing/orientation to workers, staff and contractors on their responsibility for compliance to environmental requirements of Indonesia and ADB. This orientation will also include awareness of transmitted disease such as HIV to minimize incidence in the workplace. Based on the 2018 public health data, HIV/AIDS and sexually transmitted diseases contributed to around 1.7% in Banjarnegara, 4.1% in Wonosobo, and 11% in Batang of the total medical cases treated in each district.²⁶

251. Appropriate coordination will be undertaken by the PMU and PMC to the village heads from Dieng Kulon, Kepakisan, Bakal, Karang Tengah, Sikunag, and Pranten on the planned construction schedule and progress of the construction works. They will be engaged continually to explore opportunities for local people to be involved.

5.2.4 Operation Phase

252. Prior to commissioning of SAGS, Unit 2 and its support facilities, quality assurance/quality control tests and inspections will be undertaken. Other main activities are: recruitment of workforce with required qualifications, commissioning and connection of Unit 2 to the national grid, environmental monitoring for compliance to the requirements of GOI and ADB; and appropriate O&M to ensure the reliable power generation throughout its economic life; Develop/update the HSE SOPs and other relevant protocols; and Implement HSE measures and secure international accreditation to ISO and OSHAS.

5.2.5 Decommissioning Phase

253. The economic life of the project is expected to be 30 years. Prior to the end of its economic life, GDE will conduct public consultations involving all villages in Dieng in preparing for a decommissioning plan to ensure that the same will be appropriate to the local land use plan. The decommissioning plan will cover measures to restore the site to as close as practicable to its pre-development condition and will depend on the intended use of the area and the reusability of existing facilities to other GDE facilities by that time.

5.3 Assessment of Major Impacts

5.3.1 Impact on ambient air quality

Generation of dust and vehicular emissions

254. *Dust* Dust in the form of PM₁₀ and PM_{2.5} during construction may come from excavations in the new wells, other construction support facilities like the basecamp. Dust will also be generated from the road by vehicles from equipment and material mobilization during construction affecting residential areas in Karang Tengah, Sikunang, and Pranten. Civil works-related effects during well development will be temporary and may last for about 7 months depending on the

²⁶ Sources: <https://jateng.bps.go.id/dynamictable/2019/09/20/501/jumlah-kasus-penyakit-menurut-jenis-penyakit-menurut-kabupaten-kota-di-provinsi-jawa-tengah-2018.html> (accessed 5 Oct 2019).

weather conditions. Earthworks will primarily involve excavating material, haulage, tipping and stockpiling. As in any construction site, these activities and other civil works will generate dust. Increased dust level and vehicular emissions may affect ambient air quality.

255. Dust will be generated from construction works in localized, intermittent, and low intensity as the project area has 249 rainy days in 2018 (or 68% of the year). The weather condition will serve as natural dust control. Construction schedule will consider that June, July and August have the lowest rainy days ranging from one day to 12 days while November to April have the highest rainy days. During dry months, water will be sprayed regularly to contain dust and 30km/h speed limit for construction vehicles will be enforced. Construction sites will be provided with temporary enclosures, at least 3-m high to suppress dust.

256. All the stockyards set-up by the contractors will be covered during non-working hours. Trucks that will transport construction materials will be covered with canvas or similar material to minimize dust dispersion that may annoy residents living close to the public roads going to the construction sites.

257. *Vehicular emissions* Contractor will be required to maintain construction vehicles, heavy equipment, and emergency diesel generators (if needed) regularly to minimize the contribution of vehicular emissions to ambient air quality degradation. Emissions testing certificate of service vehicles will be required and monitored by PMU. Multi-passenger vehicles will be used to transport workers to and from the construction sites. All construction vehicles and equipment will not be allowed to sit and idle for more than 30 minutes. Use of warehouse (or stockyard) onsite for construction materials will reduce trips for delivery of materials. No burning of solid or liquid wastes and other combustible materials will be allowed within the construction sites and workers' camp.

258. Workers who will be assigned to operate heavy equipment and machineries such as bulldozer, buckhoe, grader and front-end loader will be exposed to dust and vehicular emissions. PPE will be provided to ensure that they are protected. The increased number of construction vehicles to move people and materials using unpaved roads will contribute to dust generation. The public access roads to the power plant site are mostly paved with bitumen and generally in good condition in terms of dust generation. Vehicular emissions will be more of a concern than dusts.

259. The PMU Dieng will ensure that ambient air quality will not significantly deteriorate as compared to baseline values during construction phase. Regular monitoring will be conducted to confirm compliance.

H2S – Well drilling and testing

260. Well drilling will generate short and intermittent release of H₂S. This ambient releases of H₂S will be short outbursts within the work area. Workers will be provided with PPE and safety gears at the same trained in emergency cases. Ambient air quality monitoring will be conducted quarterly during well drilling phase which could last to about 18 months.

261. The noise level is likewise expected to be high for this particular test. During this test, negative impacts generally involve noise and its effect on wildlife, and release of hot geothermal fluids and its effect on nearby vegetation.

262. During well venting and testing, steam is discharged through a silencer while brine is reinjected to reinjection wells. The purpose of vertical testing is to clear the production well of drilling debris and assess if it sustains discharge. Non-condensable gases (NCG), mainly CO₂ and H₂S are released. Steam is released to confirm the well's production rate and reliability for power generation. Venting may be from a few hours to a few days. Workers that may be assigned during well testing will be provided with personal protective equipment such as ear muffs, mask, H₂S detector, and personal H₂S dosimeter with alarm system.

263. The occupational limit set by the Regulation of the Minister of Employment and Transmigration Number PER.13/MEN/X/2011 is 1,400 µg/m³ (8-hr averaging time). The WHO sets the lowest-adverse-effect level (LOAEL) of H₂S to 150 µg/m³ (24-hr averaging time) when eye irritation is caused. **Appendix 3** presents the H₂S safety technical specifications that will be implemented during well drilling and well testing. Table 5.2 presents the worker exposure limits while Table 5.3 gives the short-term symptoms and effects of H₂S. Response measures in case of H₂S release have been addressed in the relevant SOPs developed by GDE and Emergency Response Plan (**Appendix 7**). Procedure relevant to site specific H₂S management will also be developed by the drilling contractor. Routine H₂S drill will be conducted during drilling.

Table 5.2: Worker Exposure Limits to H₂S

Worker Exposure Limits
NIOSH REL (10-min. ceiling): 10 ppm
OSHA PELs: <ul style="list-style-type: none"> • General Industry Ceiling Limit: 20 ppm • General Industry Peak Limit: 50 ppm (up to 10 minutes if no other exposure during shift) • Construction 8-hour Limit: 10 ppm • Shipyard 8-hour limit: 10 ppm
NIOSH IDLH: 100 ppm
IDLH: immediately dangerous to life and health (level that interferes with the ability to escape) (NIOSH) PEL: permissible exposure limit (enforceable) (OSHA) ppm: parts per million REL: recommended exposure limit (NIOSH)
Source: US Department of Labor. Occupational Safety and Health Administration. Health Hazard, Hydrogen sulfide. https://www.osha.gov/SLTC/hydrogensulfide/hazards.html

Table 5.3: Short-term Symptoms and Effects of H₂S

Concentration (ppm)	Symptoms/Effects
0.00011-0.00033	Typical background concentrations
0.01-1.5	Odor threshold (when rotten egg smell is first noticeable to some). Odor becomes more offensive at 3-5 ppm. Above 30 ppm, odor described as sweet or sickeningly sweet.
2-5	Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep. Airway problems (bronchial constriction) in some asthma patients.

Concentration (ppm)	Symptoms/Effects
20	Possible fatigue, loss of appetite, headache, irritability, poor memory, dizziness.
50-100	Slight conjunctivitis ("gas eye") and respiratory tract irritation after 1 hour. May cause digestive upset and loss of appetite.
100	Coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours.
100-150	Loss of smell (olfactory fatigue or paralysis).
200-300	Marked conjunctivitis and respiratory tract irritation after 1 hour. Pulmonary edema may occur from prolonged exposure.
500-700	Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes.
700-1000	Rapid unconsciousness, "knockdown" or immediate collapse within 1 to 2 breaths, breathing stops, death within minutes.
1000-2000	Nearly instant death
MOEF Limit – 0.02 ppm (24-hour averaging time) Source: US Department of Labor. Occupational Safety and Health Administration. Health Hazard, Hydrogen sulfide. https://www.osha.gov/SLTC/hydrogensulfide/hazards.html	

264. H₂S emissions related to well drilling and venting are not anticipated to have significant impacts on worker's health and safety and to surrounding communities. For surrounding communities, odor may sometimes be noticeable. However, though this is a nuisance, it is not toxic and does not represent a significant health threat to communities.

H₂S – Facility Operation

265. The steam requirement for Unit 2 is estimated to be 210 tons/hr with non-condensable gas (NCG) content of 1%_{wt}. NCG is mainly CO₂ but may cause air pollution and nuisance problems due to its high H₂S content. A continuous H₂S emission will come from the cooling tower stacks during the operation phase to enhance dispersion. To assess the impacts of H₂S releases from the cooling tower, air dispersion modeling was conducted using the ISC AERMOD VIEW (AERMOD)²⁷ as the main software and several supporting commercial software such as WRPLOT View (for wind data processing), MM5 (for meteorology data processing), AERMET (meteorological preprocessor which prepares hourly surface data and upper air data for AERMOD), and AERMAP (for terrain data processing). Table 5.4 presents the source parameters used in the model.

²⁷ AERMOD modeling system is a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain. <https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models>.

Table 5.4: Source Parameters for Cooling Towers

Parameters	Unit	Unit 2	Source of Data
		(combined cycle with bottoming ORC)	
Stack height (or cooling tower height),	m	8	Project Technical Team
Stack diameter (or cooling tower diameter),	m	3	Project Technical Team
surface area,	m ²	7.065	
Stack/exit gas temperature	°K	370 (97.4°C)	Final FS (Aug 2019)
Stack/exit gas velocity	m/s	10	Project Technical Team
Actual volumetric flowrate	m ³ /s	70.65	
NCG mass rate	tons/hr	2.1	Final FS (Aug 2019)
NCG mass rate	mg/s	583,333.3	
H ₂ S mass rate, mg/s (4.2% H ₂ S in NCG)		24,500	Calculated
Volumetric flowrate at normal condition (25°C at 1 atm)	Nm ³ /s	56.88	Calculated
Number of fans		64	FS (July 2019)
Emission rate each cell	mg/Nm ³	382.81	
Concentration rate each cell*	mg/Nm ³	6.73	
*Must not exceed 30 mg/Nm ³ according to H ₂ S emission limit concentration, Ministry of Environment and Forestry Decree: No. 15/2019			

266. *Modeling domain and receptor grid* This is the area where predicted concentrations (or parameters) are calculated by the model, which in this case are the predicted dispersion concentration of H₂S. Receptors are specific locations or points in the modelling domain where predicted concentrations are computed. The receptor grid, in the form of uniform cartesian grid, was defined to be 500 m spacing grid (29 x 29 points over 14 km radius, which equals to 841 receptors) and 200 m spacing grid (30 x 30 points over 5.8 km, which equals to 900 receptors). Additional receptor groups were added as the discrete cartesian receptors for the ambient air quality locations in the modeling domain.

267. *Assessment criteria* Emission limits provided for by the Ministry of Environment Decree No. P.15/MENLHK/SETJEN/KUM.1/4/2019 on Emission Standard of Stationary Emission Source for Thermal Power Generation requires that H₂S emission should not be higher than 30 mg/Nm³ at normal conditions (temperature of 25°C and pressure of one atmosphere). The IFC-WB EHS General Guidelines and the Guideline for Geothermal Power Generation did not establish an emission standard for H₂S as this is not considered as significant releases from geothermal power plant. However, the IFC recommends that H₂S emissions “should not result in ambient concentrations above nationally-established air quality standards”. In which case, the limits that will be used for emission will be 30 mg/Nm³. H₂S level for ambient air is regulated by the Minister of Environmental Decree No 50 of 1996 on Odor Standard (MENLH, 1996). With this regulation, H₂S is considered an odor with a limit of 0.02 ppm (or 28 µg/m³). The regulations does not specify the averaging time, it is assumed, therefore as 24-hour average since it is an ambient standard.

268. *Sensitive receptor areas* Five sensitive areas were identified, based on the locations from the ANDAL Addendum 2004 and which are being monitored by GDE through a 3rd party environmental company as part of RPL for the existing Unit 1. These are Simpangan, Pawuhan, Karang Tengah, Kepakisan, Dieng Kulon.

269. *Baseline data* The available background concentrations in the areas near Unit 1 (i.e., well pad G and power plant near the ejector) could not be accurately specified as the monitoring data from GDE RPL were below the limit detection of the applied measurement method. This limit detection is quite high, i.e. <0.01 ppm or <13.9 µg/m³, half of the Indonesian odor standard of 28 µg/m³. Thus, the use of this data as the background level may not be suitable.

270. *Modeling results* The 24-hour average is determined based on average of one-hour predicted concentrations within one day calculated using 5-years hourly data of meteorology (i.e., 1 January 2014-31 December 2018 purchased from Lakes Environmental, www.webLakes.com). The maximum value of 24-hour average incremental H₂S concentration is predicted to be 372 µg/m³ (i.e. at probability of 0.06%), approximately 150 m North East of the cooling tower's stacks.

271. During operation, there will be no visible white smoke from the cooling towers as the coolant will be air. However, even without the white smoke there will be continuous release of H₂S in the cooling towers. The initial results of air quality dispersion modeling during operation indicate that incremental H₂S concentrations above 150 µg/m³ (WHO standard, 2000), where the first sign of eye irritation may occur, will be contained within a radius less than 400 m. Under normal operating conditions, the threshold value for working environment (i.e., 8-hour averaging time) of 1,400 µg/m³ as set by Regulation of the Minister of Employment and Transmigration Number PER.13/MEN/X/2011 is not expected to be exceeded (with a maximum 8-hour value of 536 µg/m³ predicted over a 5-year modeling period). Workers will be provided with appropriate PPEs as part of standard operating procedures of Unit 2. Adequate ventilation will be provided in all the work areas close to the cooling towers where ambient H₂S may occur. Per WHO, no health impact occurs at H₂S concentrations below 2,800 µg/m³.

272. The initial assessment further concludes that there is a 0.6% probability that the 24-hour average incremental H₂S concentrations will exceed the limit for odour (28 µg/m³). Such values are expected to occur primarily within a 400m radius of the cooling towers. The assessment concludes that in Karang Tengah, the nearest sensitive receptor, the probability that average 24-hour concentrations will exceed the limit for odour (28 µg/m³) is 8.8% (or some 30 days per year). However, such exceedances will be very low, with probabilities that average 24-hour concentrations exceed 56 µg/m³ (i.e. double the odour standard) and 75 µg/m³ (i.e. half the WHO recommend threshold) of 2.7% and 0.4%, respectively. The model results further indicate that the 24-hour average values will never exceed the 150 µg/m³ threshold recommended by WHO in Karang Tengah, and will not exceed the limit for odor (28 µg/m³) at the other sensitive receptors include in the assessment (i.e. Pawuhan, Kepakisan, Simpangan and Dieng Kulon. See Table 5.5) Given the climatic condition in Dieng where 8 months of the year will be rainy, this ambient H₂S level will be naturally washed out without any health effects. During the 4 months in summer where dispersion is much better, this ambient H₂S level will be dispersed downwind of the power plant farther away from the settlements. Figure 5.1 shows the air quality contour map. The full assessment is presented in Appendix 3b.

273. During DED, the air quality dispersion modeling will be conducted again once the required information such as cooling tower height, cooling tower diameter, etc., are confirmed. During that stage, the values of ambient H₂S will be much more accurate. The modeling will be conducted to

ensure that the H₂S releases will meet the emission level of 30 mg/Nm³ and ambient level for odour of 28 µg/m³ (24 hour averaging time).

Table 5.5: Predicted maximum H₂S Concentration at Sensitive Receptors, with probability of 0.06% or once in 5 years)

No.	Location	Coordinate (UTM)		Maximum 24h Ground Level Concentration (µg/m ³)
		X	Y	
1	Pawuhan	378506.12	9203995.5	13.02
2	Karang Tengah	377023.5	9203184.14	83.79
3	Kepakisan	376101.07	9204097.15	16.50
4	Simpangan	378762.36	9204585.81	26.69
5	Dieng Kulon	379521.06	9202659.82	26.12

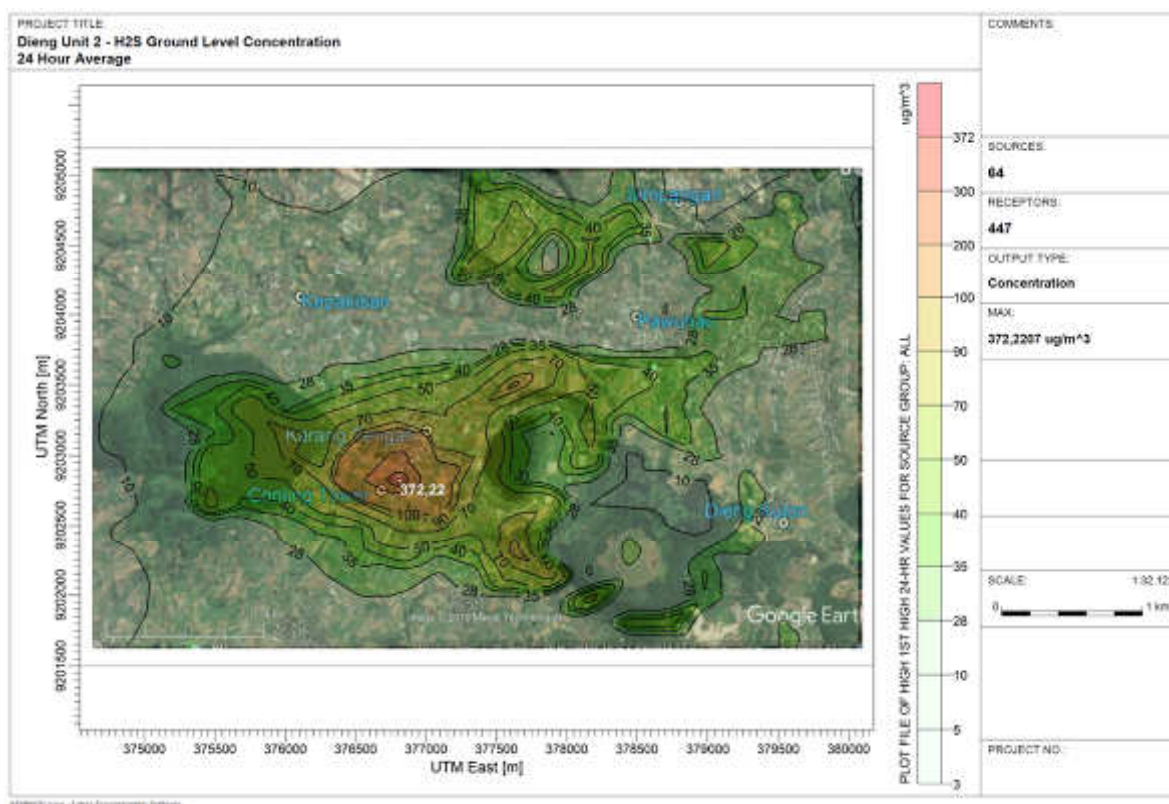


Figure 5.1: Maximum 24-h H₂S levels within the Modeling Domain (@ probability of 0.06%, or one in 5 years)

H₂S - SAGS

274. This includes all well pads and surface facilities required to produce, transport and process geothermal fluids to deliver brine to the power plant. SAGS also includes facilities to dispose waste waters.

275. SAGS emit H₂S from the rock mufflers. Rock mufflers are four-sided, concrete-walled structures with a multi-armed slotted diffusers to allow for the release of steam to control operating pressure in the power plant. Rock mufflers are designed to significantly reduce noise levels and droplet emissions generated by the expansion of steam when released to the atmosphere. “Stacking” or venting of steam through the rock mufflers occurs as incident only whenever there is an upset at the power plant or continuously as “trim” when there is an excess of steam supply over demand of the power plant. Stacking and trimming constitute a waste of steam and carries NCG contributing to ambient H₂S levels. These activities are minimized to the extent possible.

276. The amount of H₂S from venting depends on the flow of steam. Trim venting can be for days or occurs as small wisps of steam instead of the large plume emitted when a turbine trips off.

277. Another source of H₂S that may be considered continuous but minor are drain pots (or steam traps) provided at varying intervals along the single-phase steam pipelines. These drain pots allow for draining of particles and condensate. Maximum H₂S concentration emitted by one drain pot (0.635 cm orifice at 8.44 kg/cm²) is estimated to be 75 g/hr. H₂S emissions from drain pots are only significant within 1 m from the source. Release of steam from drain pots generates noise also.

278. The short-term symptoms and effects of H₂S and the exposure limits to workers are shown in Table 5.4.

5.3.2 Noise

279. Results of ambient noise level monitoring from the RPL of Dieng Unit 1 indicate compliance with the MoE decree No. 48/1996 on noise and the IFC-WB EHS General Guidelines (Table 1.7.1).

280. In the context of the IEE for the project the acoustic impact of the drilling, venting activities during construction and of the new power plants in Dieng during operation was assessed. While the project will only support construction of Unit 2, the assessment included Units 2 and 3 to allow for cumulative impact assessment. The noise study was conducted by an independent, qualified consulting firm. The full study, presented in Appendix 5b, is based on the estimated sound emissions of the acoustically relevant components of the drilling activities and the power plants and determines the acoustic effect on the surrounding areas.

281. The magnitude of incremental noise during equipment mobilization is not anticipated to be substantial and the frequency is low (i.e only during the passing of vehicles). However, consulted communities have raised it as a potential issue during pre-construction and construction. GDE plans to undertake the hauling of equipment and supplies during mobilization at night time to avoid congestion, accidents and minimize disturbance at the residential areas. The noise to be generated may exceed the standard for residential areas at night time which is 45 dB(A) or 3dB(A) more than the baseline values. To ensure that strict implementation of slowing down in residential

zones will be observed, traffic marshals shall be provided at all times. Vehicle speed will be limited in residential areas to reduce dust as well as noise generation.

282. For the operation phase, a digital 3-D acoustic model for sound propagation calculations has been established and used to predict and simulate the sound field around the drilling equipment and the power plants (Unit 2 and 3), i.e. the sound pressure level contributions of these items. Based on the results an assessment has been made to determine whether the acoustic impact of the said activities is in compliance with the relevant acoustic requirements.

283. *Modeling assumptions* According to ADB's Safeguard Policy Statement (2009), the acoustic impact of the new power plants (Unit 2 and Unit 3) and the associated well drilling and testing activities is to be assessed by comparison to the acoustic criteria specified by ADB. These are based on the limits defined in Indonesian legislation and the World Bank Group's Environmental, Health and Safety Guidelines (WBG EHS Guidelines 2007). The assessment in this study is based on the following acoustic criteria (all referring to A-weighted sound levels):

- Noise limit criterion: Compliance is achieved if the rating level determined at a specific noise-sensitive receptor (NSR) does not exceed the maximum permissible sound level at the NSR.
- 3 dB criterion: The 3 dB criterion is relevant if the noise limit criterion is not fulfilled, i.e. if the rating level determined at a specific NSR exceeds the maximum permissible sound level at the NSR. In this case, compliance is achieved if the difference between the rating level and the baseline level at the NSR is not greater than 3 dB.

284. Table 5.6 lists the noise sensitive receptors for which the noise criteria have been checked in this study and the maximum permissible sound pressure levels ("noise limits") at these NSRs.

Table 5.6: Noise-sensitive receptors in Dieng

NSR	Name	Noise limit day / night in dB(A)	
		Day	Night
NSR 1	Dieng Kulon	55	45
NSR 2	Dieng	55	45
NSR 3	Karang Tengah	55	45
NSR 4	Bakal	55	45
NSR 5	Kepakisan	55	45
NSR 6	Pekasiran	55	45
NSR 7	Sikunang Village	55	45
N-10	Power Plant	70	70

285. For the following operating scenarios the contribution level (= the sound pressure level contribution) from the sound sources associated to the scenario were simulated:

- **Scenario D-C1** (Construction phase, well development)
 - Drilling equipment operational
- **Scenario D-C2** (Construction phase, well development)
 - Drilling equipment operational and
 - Well steam testing (steam blowing tests) in progress

- **Scenario D-O0** (Operational phase)
 - Unit 1 operational
- **Scenario D-O1** (Operational phase)
 - Unit 2 operational
- **Scenario D-O5** (Operational phase)
 - Unit 2 operational and
 - Unit 3 operational

286. For all scenarios, simulations were performed for the active power plant(s) or drilling equipment in normal, failure-free operation. Special operating conditions such as start-up, shutdown, emergencies or by-pass operation are not taken into account in this study. Given the very high sound pressure contributions from steam tests, the model simulation assumed that a portable rock muffler as described in *Amri et al* (2019)²⁸ will be in place for the steam tests.

287. **Modeling results** The calculated A-weighted downwind sound pressure levels LA(DW) of the noise received at the NSRs are listed in Table 5.7 for the five operating scenarios D-O0, D-O1, D-O5, D-C1 and D-C2.

Table 5.7: Calculated A-weighted downwind sound pressure level LA(DW) at the NSRs (contribution level) at 1,5 m above ground for operating scenarios D-O0, D-O1, D-O5, D-C1 and D-C2

A-weighted sound pressure level $L_A(DW)$ in dB(A)					
	Operational phase			Construction phase, well development	
NSR	D-O0	D-O1	D-O5	D-C1	D-C2
NSR 1	10.3	18.3	20.2	59.2	63.5
NSR 2	15.2	20.3	23.0	46.0	49.8
NSR 3	19.0	43.2	46.4	44.5	48.1
NSR 4	21.0	25.2	27.7	29.7	32.4
NSR 5	14.6	30.0	33.0	47.6	51.7
NSR 6	10.7	17.6	20.8	26.9	29.4
NSR 7	36.8	21.8	25.0	27.9	30.6
N-10	51.2	24.7	27.9	31.3	34.2

288. The sound pressure field around the three power plants (Unit 1, Unit 2/3) has been computed by use of the 3-D acoustic calculation model for operating scenario D-O0 (Unit 1 operational) and the following combinations of D-O0 with the other operational phase scenarios:

- Scenario D-O0 plus D-O1 – referred to as D-O2 (Unit 1 + Unit 2 operational)
- Scenario D-O0 plus D-O5 – referred to as D-O3 (Unit 1 + Unit 2 + Unit 3 operational)

289. The results are presented as sound field contour plots in Figures B1 to B3 of Appendix 5b with contour lines of equal sound pressure levels which show the calculated total A-weighted

²⁸ Amri Zein, Paul A. Taylor, Yudi Indrinanto, Heribertus Dwi Yudha: Portable Rock Muffler Tank for Well Testing Purpose. Proceedings of the World Geothermal Congress 2010. Bali, Indonesia, 25-29 April 2010.

downwind sound pressure levels LA(DW) received from the power plants (contribution level). The contour plots for scenario D-05 (all units in operation) are presented in Figure 5.1.

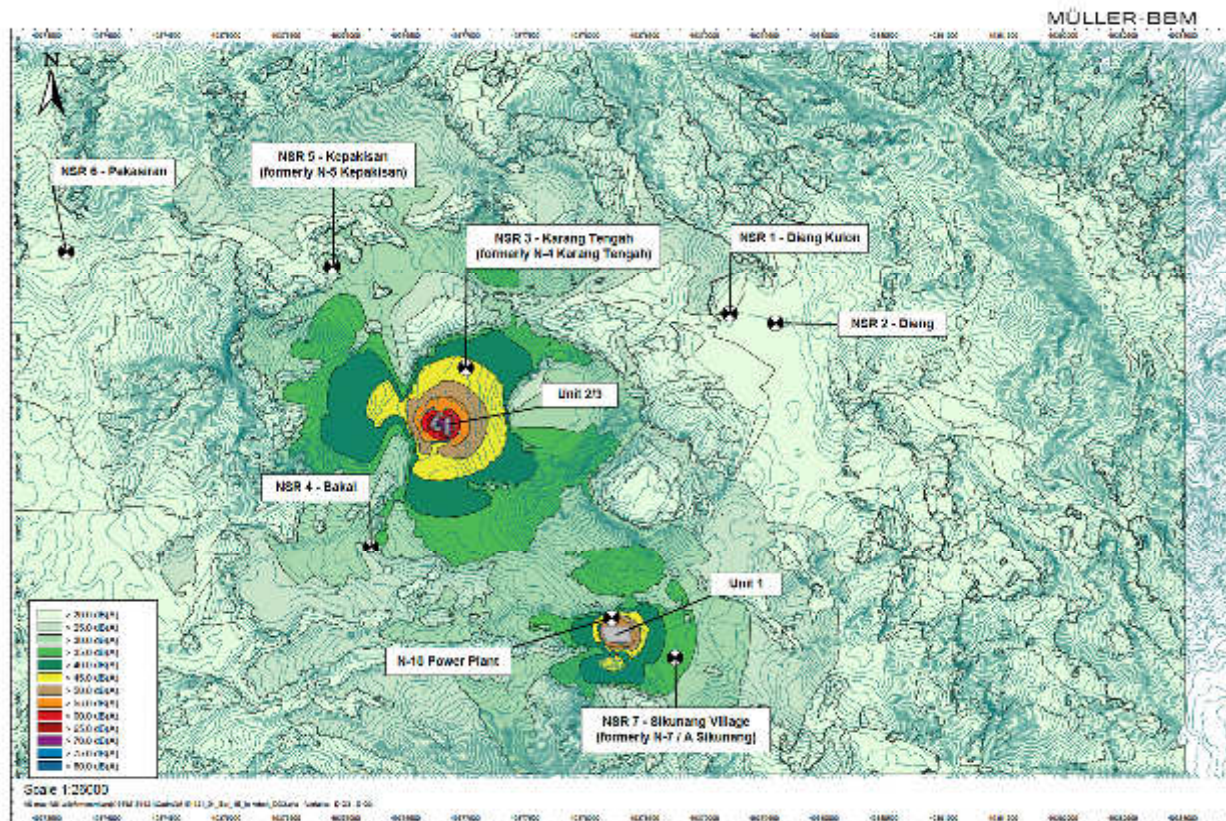


Figure 5.1: A-weighted sound pressure levels (LA(Lt)) at 1.5m above ground for scenario D-02 (Unit 1, Unit 2 and Unit 3 – contribution)

290. A compliance overview is shown in Table 5.7. It specifies if the assessment shows overall compliance or not with the acoustic criteria or if it cannot be clearly decided if compliance is achieved ("unclear").²⁹

Table 5.8: Overall compliance overview

	Overall compliance achieved?			
	Operational phase		Construction phase, well development	
NSR	D-01	D-05	D-C1	D-C2
NSR 1	yes (d)	yes (d)	unclear	unclear
NSR 2	yes (d)	yes (d)	unclear	unclear
NSR 3	yes (b)	yes (b)	yes (b)	yes (b)
NSR 4	yes (d)	yes (d)	yes (d)	yes (d)

²⁹ "unclear" signals a potential non-compliance. This is the case when no noise monitoring data is available for an NSR (= baseline level unknown) but the noise contributions are close to the maximum permissible sound level or exceed the maximum permissible sound level.

Overall compliance achieved?				
	Operational phase		Construction phase, well development	
NSR 5	yes (d)	yes (d)	unclear	unclear
NSR 6	yes (d)	yes (d)	yes (d)	yes (d)
NSR 7	yes (b)	yes (b)	yes (b)	yes (b)
N-10	yes (a)	yes (a)	yes (a)	yes (a)

291. **Discussion** As shown in Table 5.8, the following can be concluded:

- For all operational scenarios (D-O1, D-O5):
 - compliance is achieved at all NSRs
- For all construction scenarios (D-C1, D-C2):
 - compliance is achieved at NSR 3, 4, 6, 7 and N-10.
 - compliance "unclear" is expected at
 - NSR 1 and 2 (construction at well pad TCH-1)
 - NSR 5 (construction at well pad H)
 - for the higher day-time limit of 55 dB(A) compliance "unclear" is expected at
 - NSR 1 (construction at well pad TCH-1)
 - (NSR 2 and NSR 5 are compliant in this case for D-C1 and D-C2, "yes (d)")

292. Accordingly, situations with unclear compliance are only obtained at

- 3 NSRs for noise limit 45 dB(A);
- 1 NSR for noise limit 55 dB(A);
- and all for the construction phase, well development scenarios when drilling or drilling with steam testing takes place at the well pad next to the respective NSR.

293. Assuming that indeed non-compliance is caused by the activities during well development in the construction phase, reducing the sound emissions from drilling and well steam testing will require additional noise control measures that come at considerable efforts and costs and that may even be technically challenging. In view of this and because construction goes on for a limited time only – steam testing even more so – it may be justified to apply for an exception with the authorities. Affected residents could be compensated adequately for days / nights with excessive noise levels.

294. Furthermore, normally only a limited number of residents living in the houses at the limits of a village will be affected because all others should benefit from the acoustic barrier effect from the houses "in the first row".

295. A key requirement will be the application of a (mobile) rock muffler or silencer during well venting, as described in *Amri et al* (2019).³⁰ The EPC contractor will also be required to conduct more detailed noise impact study at detailed design stage, i.e. once the exact site of the powerplant and noise emitting components are defined. The EPC contractor will be required to

³⁰ Amri Zein, Paul A. Taylor, Yudi Indrinanto, Heribertus Dwiudha: Portable Rock Muffler Tank for Well Testing Purpose. Proceedings of the World Geothermal Congress 2010. Bali, Indonesia, 25-29 April 2010.

demonstrate compliance with the criteria listed above, and the results shall be shared with nearby communities.

5.3.3 Water use and impact on local water resource

Water demand for facility construction and operation

296. Geothermal power plants are known to consume less water per kilowatt-hour (kWh) of lifetime energy output than other electric power generation technologies.³¹ Clark *et al* estimated in their 2010 study that a system such as the one proposed in Dieng consumes in average 1.02 L/kWh of lifetime energy output, many times less than coal-, nuclear-, gas- or biomass-based electric power generation.³² However, water consumption during facility installation, especially during well drilling, can be significant and may potentially affect local water availability if not properly planned.

297. During **facility construction**, water is consumed in the drilling of geothermal production and injection wells both in drilling muds and in the cement used to construct the wells. Water is also consumed in the concrete often used in support structures for pipelines that transport the geofluid from production wells and to injection wells and in the construction of the power plant itself.³³ Recent LCA studies show that the largest volume of water during construction is used for drilling wells, and the second largest volume is attributable to cementing the well casing into place. The water volumes required for the concrete in the power plant construction and the pipeline support foundations are significantly less than the volumes required for well construction.

298. The drilling of the 10 wells in Dieng (5 production wells, 5 injection wells) will require significant amounts of freshwater. When drilling for surface casing, basic fresh water-bentonite based mud will be used. Other sections of the wells will apply aerated fluid drilling. According to the latest project implementation schedule as documented in the final FS (June 2019), well drilling will be conducted from Spring-Summer 2020 until Spring 2022. i.e. over a period of 18-24 months.

299. Water demand for well drilling typically averages 225-500 m³ per 100m of well depth. Assuming an average well depth of 1,000m for the 11 wells to be drilled in Dieng, this would result in a total water volume of approximately 25,000-55,000 m³. The FS estimates that the peak water demand will amount to 30 to 50L/s, i.e. during the drilling of 12 ¼ inches production wells. Assuming that water injection is interrupted during the rig maneuvering (corresponding to 30% of the operation time), and the reuse of up to 85% of the injected water (which is returned to the surface with extracted cuttings), hourly peak water demand is expected to be in the range of 18 to 125 m³/h, strongly depending on the permeability of the formation.

300. However, drilling water requirements in the presence of heavy circulation losses (i.e. where permeability of the formation is high) can be reduced by using underbalanced air drilling (i.e.,

³¹ Only photovoltaic electric power systems reportedly consume less water than binary geothermal power systems the one proposed in Dieng.

³² Clark C, Harto C, Sullivan J, Wang M. 2010. Water Use in the Development and Operation of Geothermal Power Plants. Environmental Science Division, Energy Systems Division, Argonne National Laboratory, US Department of Energy. ANL/EVS/R-10/5

³³ Harto C, Schroeder J, Martino L, Horner R. Clark C. 2013. Geothermal Energy: The Energy-Water Nexus. Proceedings, 38th Workshop on Geothermal Reservoir Engineering. Stanford University, Stanford, California.

aerated drilling mud).³⁴ This will be the main drilling approach in the production section of the wells, to be further evaluated in the phase of well drilling detailed design.

301. **Freshwater use during operation** is very much dependent on type of cooling system used. The feasibility study has looked at various cooling system options, including the use of condensate or fresh water in a wet cooling system, or the use of a dry cooling system. The FS concludes that the use of condensate in a wet cooling tower is not recommended, because condensate oxygenation would dramatically increase corrosion in the reinjection system. A wet cooling tower with fresh water is also not deemed feasible, because it would require a continuous water make-up of around 70 m³/h (or 20 L/s) which is not available in Dieng. Instead, the FS recommends the use of an air-cooled condenser. There is no direct water consumption for dry cooling, however there will be water consumption for other operational activities including dust suppression, maintenance, and domestic needs, typically ranging from 0.03 to 0.45 L/kWh (Table 5.9).

Table 5.9: Anticipated water demand during facility construction and operation

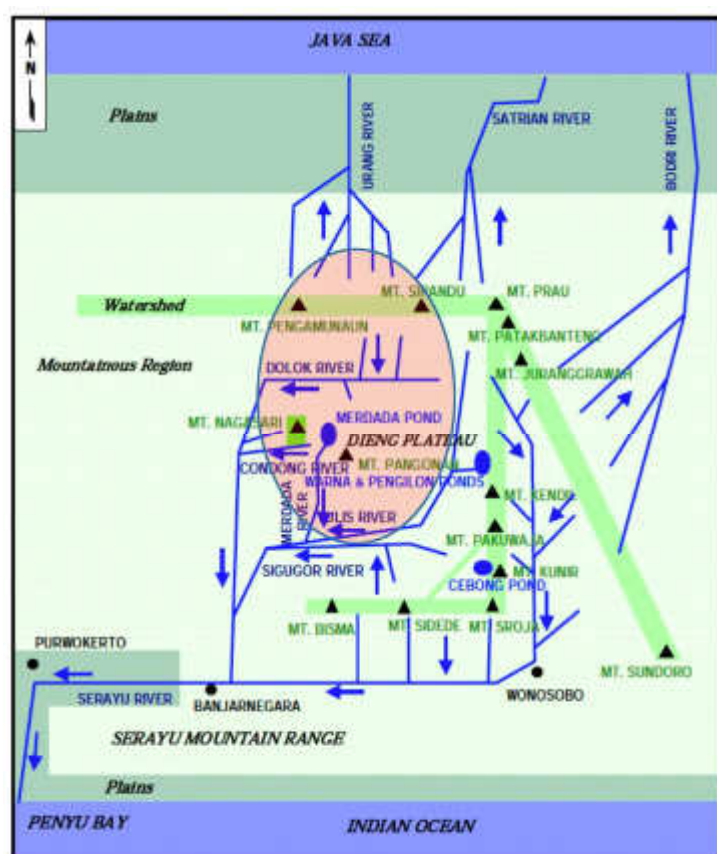
Stage	Peak water use	Total freshwater demand
Construction	18-125 m ³ /h (peak: 50L/s during normal operations, 80L/s during emergency situations)	25,000-50,000 m ³ per well
Operation	40-600 m ³ /d	0.03-0.45 L/kWh LCA, or 15,000-230,000 m ³ per year

Water sources in Dieng

302. Dieng is situated in the Central Java highlands, at an elevation of about 1,800 to 2,100 m asl. The average annual rainfall on the Dieng Plateau is 260 cm. However, during the dry season from July to September, rainfall may be as low as 3-8 cm per month. Agriculture relies exclusively on precipitation given the depth of the freshwater aquifer and the high content of H₂S naturally occurring in many underground sources. Irrigation water is supplied from natural lakes, ponds and streams through a dense network of small-bore irrigation pipes installed individually by farmers. Given the location of the Dieng Plateau, the catchment area of these natural water bodies is small and as a result seasonal variability is high.

303. The project area is crossed by several streams and rivers (Figure 5.2). The main water bodies include the Merdada, Warna and Pengilon ponds, and the Cidolok, Tulis and Urang rivers.

³⁴ Typically, approximately 30 L/s will be 'lost to the formation' while drilling an 8 1/2 inches hole 'blind with water'.



(Source: Dieng Feasibility Study Update, June 2019)

Figure 5.2: Surface water bodies in and around Dieng Plateau.

Suitability of fresh water sources for drilling

304. Merdada pond is the largest natural pond in the area; its location near Pad 9 would be ideal to provide water for drilling; unfortunately, its water is acidic and not suitable for drilling uses. Warna and Pengilon ponds are natural ponds inside a crater; even in these cases, their acidic water is not suitable for drilling purposes. Thus none of the natural ponds is a suitable water source for well drilling.

305. Cidolok River is the main river crossing the Sileri area. While long-term water flowrates are not available, recent monitoring conducted in 2018 indicate a range between 87 L/s and 123 L/s. Cidolok river is an important source of water for farmers especially during the dry season.

306. Tulis River is outside the Sileri area, but represents the most interesting alternative to Cidolok River as source of freshwater for well drilling. The river is about 2.5 km far from the closest well pad; a water intake has already been built and equipped with pumps. Recent flow rate measurements indicate flow rates of 105 to 156 L/s.

307. Urang River is located in the North of the Sileri area, beyond the watershed, where agricultural needs are very low; its exploitability would be very useful for drilling in pads 10 and 33; however, its flow rate at the time of the Consultant's survey (March 2019) was extremely low (few liters per second) and surely not sufficient to represent an useful water source (Table 5.10).

Table 5.10: Surface water bodies in the project area of influence

Water body	Characteristics, flow rates	Suitability as water source for well drilling
Merdada pond	Acidic water, important irrigation water source	Not suitable
Warna	Acidic water	Not suitable
Pengilon ponds	Acidic water	Not suitable
Cidolok river	Main river in the project area; 80-120 L/s average flow rates; main water source for farmland irrigation. Water extraction point already constructed	Suitable, with extraction restrictions (max. 20L/s during normal operation, no extraction during dry season)
Tulis river	2.5km from project area; 100-150 L/s average flow rates; important water source for farmland irrigation; water extraction point already constructed.	Suitable, with extraction restrictions (max. 20L/s during normal operation, no extraction during dry season)
Urang river	Very low flow rates.	Not suitable

308. Given the importance of water for agriculture in the project area, alternative water sources were investigated as part of the feasibility study update. The only valuable alternative water source is condensate from Unit 1. With an average flow rate of 30 L/s, this water source is always available. Given the shortage of water in dry seasons, the use of the condensate is recommended as the primary source of drilling water. The existing pipelines in Sikidang area can convey this condensate to Pad 24, where a pond of about 1,800 m³ is also available for storage, subject to rehabilitation (Figure 5.3).

**Figure 5.3: Existing freshwater storage pond at Pad 24**

Proposed water supply during normal operations

309. Each well will take approximately 60 days to drill and there is then a period of 7 – 10 days to move the rig to a new location before drilling starts again. Under normal operating conditions of Unit 1, condensate production and supply is expected to be sufficient to cover average water demand (30L/s) for drilling operations under normal conditions. Water demand on the rig is reasonably low during the early part of a well and the supply of condensate from the power plant is more than adequate to feed the rig and keep the reservoir full. The reason for this is that the rig drills with mud and most of this recirculates to the surface, flushing the drill cuttings with it. The mud is filtered to remove cuttings and then pumped back down the hole again. So water is only needed for make-up.

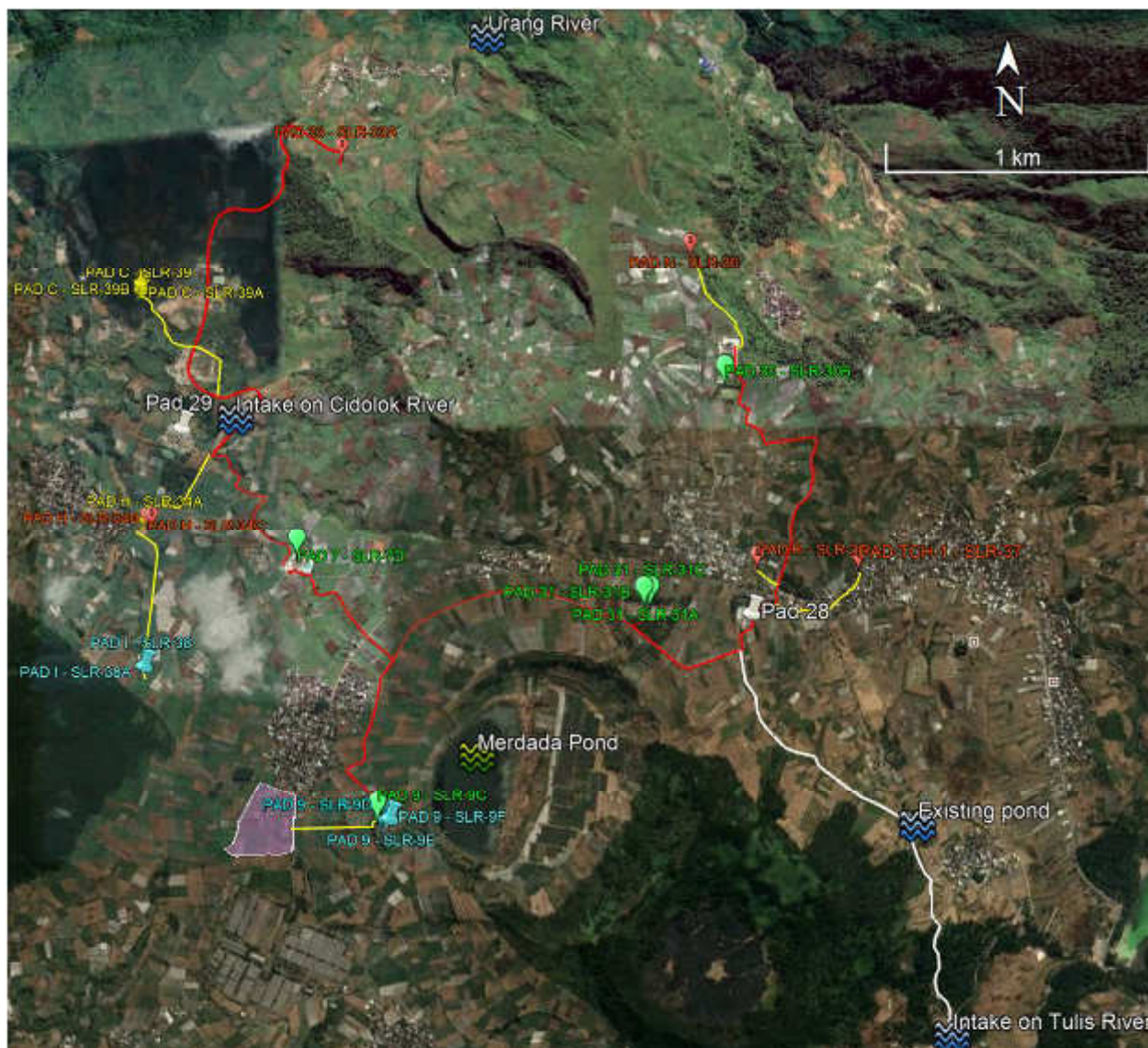
310. However, during the latter stages of the well, there will be periods of lost circulation where the mud (and water) is lost into cracks in the formation and does not return to surface. At this stage, the rig will stop using mud (as it clogs up the formation and reduces the productivity of a well when it is completed) and continues drilling with water which is pumped into the formation and lost. At this stage, the demand from the rig can be greater than the available condensate supply from the power plant and will need to be drawn from the nearby rivers. It is estimated that a maximum of 35 L/s from the river will be required for 2 – 3 days, and will then be able to stop drawing from the rivers for 1 – 2 days and would then draw at 35 L/s for another couple of days. This could happen for a period of up to three weeks toward the end of the 60-day drilling cycle, and would not happen until the same timeframe on the next well. Tulis River and Cidolok River can supply the difference, i.e. up to 20L/s each. The exploitation of both rivers allows to reduce the extraction rate and minimize the impact on agricultural needs.

311. Intake facilities are already available on Cidolok River and Tulis River. The pipeline from Tulis River to the Sileri area passes near a 1800 m³ pond at Pad 24 that will be expanded to 20,000 m³ and used for water storage.

312. Fresh water supply and thus pressure on the Tulis and Cidolok rivers will be further minimized through multiple measures:

- (i) Reuse of water-bentonite based mud. The mud will be stored after the drilling of one section and reused in the next section as long as the mud is still in usable condition. This is expected to reduce the total volume of water required for drilling by approximately 70-80%;
- (ii) Application of aerated fluid drilling: Aerated fluid drilling i.e. clay-free) will be used for the production zones of the wells;
- (iii) No water extraction during the dry season (July to September): given the dependence of farmers on river water for irrigation of their agricultural fields, no water extraction for drilling purposes shall be allowed during July to September.
- (iv) Construction of additional reservoir at new power plant site (Unit 2) of 5,000 m³ to supply peak water demand (including construction of power plant).

313. The drilling services contractors will keep records on daily operations, which will include – but not limited to - volumes of water used, segregated by source of water used.



(Source: Dieng Feasibility Study Update, June 2019)

Figure 5.4: Water supply arrangements during drilling operations

Proposed water supply for emergency situations (drilling)

314. In case of accident, as occurred during the 1995 – 1998 drilling program, up to 80 L/s of water may be required. In this case, during dry seasons, the condensate from Unit 1 and the two rivers may be not enough to supply the required amount of water without additional storage facility. For that purpose, the existing storage pond at Pad 24 will be expanded to 20,000m³. This increased reservoir may assure the water supply during peak demand (80 L/s) for:

- almost 3 days if no other source is exploited;
- 4.6 days if 30 L/s of condensate from Unit 1 is available;
- more than 1 week if Rivers Tulis and Cidolok may integrate with about 10 L/s each.

315. This arrangement will provide sufficient time to install an emergency water well. Considering the mobilization time and the possibility of unsuccess with the first drilling, it may be assumed that a water well may start supplying water in about 4 days.

Conclusion

316. Three possible sources of water for drilling have been identified, including condensate of Unit 1, Cidolok and Tulis River. Other water sources cannot be used. Peak amount of water required for drilling is estimated at about 50 L/s, with maximum peaks of 80 L/s in case of emergencies.

317. A set of measures has been identified that will contribute to securing supply of high quality freshwater for drilling purposes without affecting the environment and other water users, primarily farmers that heavily rely on limited freshwater resources in the area.

318. Peak water demand during normal drilling operations can be covered with 30 L/s of condensate from Unit 1 and with about 10 L/s from the Cidolok and Tulis River during peak water demand under normal operations. The availability of a pond near Pad 24 (to be expanded under the project) and a new pond in the power plant area (5,000 m³), represent a reserve for short peak demands especially during emergency situations.

319. Water extraction from the Tulis and Cidolok Rivers will be limited to 10 L/s each during normal operations and to 20 L/s during emergency situations. This will ensure that extraction rates will not exceed 20% of average flows. River water extraction during the dry season, i.e. from July to September, will not be allowed.

320. All water saving measures, including their water saving benefit as compared to the Business as Usual (BAU) scenario, are presented in Table 5.7.

Table 5.11: Freshwater saving measures considered in project design

Phase	Measure	Benefit
Construction phase	Drill only one well at once (only 1 rig will be installed)	Minimized peak water demand (capped at 50L/s under normal operations)
	Use various water sources, including condensate of Unit 1, Tulis and Cidolok rivers	Redundancy in water sources, reducing risks of water shortage
	Use condensate from Unit 1 (30L/s) as primary water source	Cumulative river water extraction limited to 20L/s during normal drilling operations, or approx. 15-20% of average flow.
	Apply aerated drilling fluid whenever possible	Total water loss to well (in permeable production zone) reduced by up to 30 L/s.
	Drilling during the dry season (July-December) shall exclusively rely on condensate from Unit 1; use of river water shall be discontinued during that period.	Minimized risk of water conflicts with other water users during dry season, especially local farmers.
	Installation of freshwater reservoirs at Unit 2 powerplant (5,000 m ³) and Pad No. 24 (20,000 m ³)	Improved management of peak water demand; with reduced total river water extraction as a result.

Operation phase	Adopt air cooling technology (as opposed to water cooling)	Average water consumption reduced by up to 20L/s
-----------------	--	--

5.3.4 Impact on surface and groundwater quality

321. Earthwork activities for construction of access roads, the power plant and associated facilities as well as cut and fill activity may change surface run-off patterns and cause localized erosion and sedimentation. With adequate surface runoff management at well pads and the power plant, TSS of runoff is not expected to exceed 100 mg/L. Erosion is not expected to significantly affect water quality of waterways.

322. Groundwater will not be used for drilling activities. Drilling wastes are collected in sumps lined with impermeable liner to prevent shallow groundwater contamination. However, during heavy rains, sumps may overflow through discharge pipes located in the sumps wall.

323. In Dieng, it is rainy more than half of the year. This climatic condition will be considered during drilling activities. In the event of heavy rains, the combined volume of produced fluids and rainwaters can lead to the flow of sump waters over the sump berms; and failure of sump walls. Fluids and sediment could be released in both circumstances but will not significantly affect surface water quality as the wells are not located close to the surface water sources.

324. To prevent sump wall failures, berms will be compacted during sump construction as much as possible and will be inspected following construction. Sump overflow pipes will be checked for structural integrity to prevent leakage within the sump wall.

325. Groundwater contamination will be unlikely since design of sump and construction practices ensure sump location in original ground, lined, and leak-testing of sumps. After drilling, the wells will be properly cemented and cased off to prevent groundwater contamination and cooling of geothermal wells (Figure 5.5). Additional protection measure involves early detection and remediation of leaks. Given the short duration of drilling activities, this limits any groundwater contamination within the vicinity of the drilling area. Geothermal resource is in a depth much deeper (1,500 m at least) than groundwater and no interaction will occur.

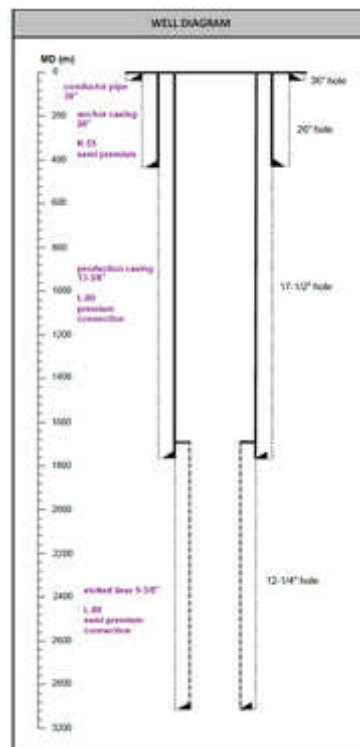


Figure 5.5: Design of well casing

326. Groundwater resources are adequately protected from fluids contained in the sumps by adopting the following: (a) proper selection of sump site on original ground as much as possible, (b) compaction of soil at the sump bottom followed by lining with impermeable material, and (c) conduct of leakage tests. Monitoring of the sump status will also be a regular activity.

5.3.5 Generation of Waste

327. Construction activities and workers will generate waste that if not handled properly will adversely affect the environment. Each contractor will be required, as part of their contractor EMP (CEMP), to prepare a waste management plan which will be part of the overall construction management plan. Appropriate garbage bins will be provided by each contractor in all construction sites and workers will be required to segregate waste. Given the state of municipal solid waste management in Banjarnegara and Wonosobo, each contractor will be required to clearly define the solid waste management during construction. Each contractor will ensure that workers will not irresponsibly throw their garbage particularly near or in Tulis River and Cidolog River.

328. GDE Unit 1 implements waste segregation as a requirement of their accreditation to the ISO 14001 on environmental management system. In principle, waste will be managed in accordance with GDE SOPs SOP-037-R1 and SOP-038-R1 (Table 4.26).

329. Heavy equipment and machinery workshops will be bunded or lined with impermeable material to prevent spills directly on land. Oil and water separator will be provided for oily waste and washings. Workers' camp will have adequate and appropriate garbage bins, and good housekeeping will be observed at all times.

Well drilling

330. The waste drilling fluids and produced waters from well testing will be collected in the adjacent sumps to be installed as part of well development. These wastes are fluids and materials generated from the drilling process which include rock cuttings, excess drilling mud and rig washings. Drilling waste is not considered as hazardous as they are mainly bentonite. These are left to evaporate in the sump, or to be used as water sources for subsequent drilling activities. The estimated dry cuttings will be 37.8 m³ (nominal open hole volume) per well while wet cuttings with 10% mud will be 42.6 m³. The sumps are lined with impermeable material to prevent soil and water contamination.

331. Drilling mud and cementing materials are not considered as hazardous. The choice of drilling mud components and cementing additives are tested through the standards of TCLP (Toxicity Characteristic Leaching Procedure) standards. Table 5.4 shows the drilling and cementing materials.

Table 5.12: Drilling and Cementing Materials

Drilling F-Mud Materials	Cementing Materials and Additives
Bentonite, Barite (no need under normal conditions, it should be ready at the location-each well), Caustic Soda, Soda Ash, CF Ligonosulfonate, Sodium Bicarbonate, Pac-R Resinex, Lime, Glisonite (L), XCD Polymers, LCM, Aliminum Stearete, Foamer (L) Scale Inhibitor (L) Drilling Detergent Zinc Carbonate Corrosion Inhibitors L Drilling Detergent (L) Zinc Carbonate Spot Material (emergency)	API G Class Cement, Silica flour, Spherelite, Retarder, Friction Reducer, Latex-HT (L), and De-foamer

332. Oil-water separators will be provided in the temporary workshops to handle the spent waste oil and lubricants. Basecamp will be provided with appropriate garbage bins in order to minimize generation of solid waste. The contractor will be required to have a waste management plan approved by the PMC and GDE PMU at Dieng.

Powerplant Operation

333. The air-cooled cooling tower will not generate sludge compared to the wet-cooling tower. Wastewater will mainly come from workers and staff of Unit 2 and from the laboratory resulting from the daily analyses of geothermal and environmental parameters. Septic tanks will handle domestic wastewater while laboratory wastes can be neutralized and mix with waste to injection wells.

334. Machinery scales, used batteries and lamps, wire cuttings, used oil/lubricants, expired/unused chemicals are some of the solid wastes from the power plant which may be hazardous. A designated storage area for hazardous/toxic waste will be provided which will be equipped with emergency eyewash, fire-fighting system, and shower/wash area. The storage for hazardous waste will be bunded or lined with impermeable material to prevent soil contamination.

All the hazardous waste stored will be properly labeled following SOP-037-RI. GDE implements waste segregation in Dieng Unit 1 with bins appropriately labeled provided in strategic locations. These procedures will be similarly enforced in Unit 2.

5.3.6 Impacts on Land, Agriculture, Risk of Natural Disasters

Well drilling, powerplant construction

335. Improper disposal of waste generated from construction may cause soil contamination. An oil-water separator will be provided at the construction sites. All refueling will be monitored by designated staff and vehicles will not be left unattended while refueling is ongoing to avoid spills. There may be a possibility for improper disposal of construction debris and other wastes. Contractor will provide adequate garbage bins and will require workers to segregate waste for easier collection and disposal. Waste segregation is implemented in Dieng Unit 1. This will be maintained in the construction sites. Prior to construction works, contractors will be required to identify how solid waste generated will be disposed of.

336. Construction of power plant and supporting facilities will require excavation. A “chance find” procedures is given in Appendix 2 that will be followed by the Contractors in the event a physical cultural resource, as defined by SPS 2009, is encountered.

337. The contractor will be required to ensure that post-construction clean-up of all construction debris and other waste generated will be disposed of properly. A waste management plan following the requirements of GDE HSE SOP (i.e. SOP-037-R1 on hazardous and toxic waste, SOP-038-R1 for non-hazardous and non-toxic will be prepared by the Contractor for approval by the PMU.

Powerplant Operation

338. The project is not anticipated to generate significant amounts of waste or emissions that could impact soil quality.

339. As a whole, the project area is potentially exposed to landslides. The power plant (unit 2) is located on a relatively low sloping area, away from water courses and therefore not considered at risk of flooding. However, the during DED, the EPC contractor will be required to (i) conduct seismic hazard study and demonstrate that power plant structural design is seismically safe for anticipated seismic risks. The structural design is to be checked by a suitably qualified and experienced third-party structural engineer who is independent of GDE, their designer and contractor; (ii) conduct detailed site investigation including flood and landslide risk assessment.

340. Total reinjection of brine during well drilling and testing will be implemented, thus avoiding risk of pollution of soils and agriculture areas under normal operating conditions. In the unlikely case the sump overflows and reaches farms nearby, crops may be damaged. In this case, compensation will be given to affected farmers based on national regulations. Sumps will be designed to adequately to consider the rainfall events in Dieng and monitoring of its working condition will be conducted.

5.3.7 Impact on fauna, flora, biodiversity

341. A Critical Habitat Assessment (CHA) and Biodiversity Action Plan (BAP) were prepared by an independent international biodiversity expert in the framework of this IEE to assess the project's impact on critical habitat classifying biodiversity and demonstrate no net loss of biodiversity. The full BAP is presented in Appendix 6b. The BAP assesses the presence of Critical and Natural Habitat in the Project area (BAP Section 3; Appendix A), evaluates potential impacts on priority biodiversity (BAP Section 4), outlines Project commitments to mitigation and management measures to achieve at least no net loss for Critical and Natural Habitat (BAP Section 5). The following sections summarize the CHA/BAP main findings.

342. Critical-habitat qualifying biodiversity.

343. The Critical Habitat Assessment, presented in Section 4.3.4 of this IEE, used a broad Dieng Mountains Area of Analysis (AoA) to assess Project risks. The assessment identified the AoA to be likely or actual Critical Habitat for one globally Critically Endangered and two Endangered primates, the Critically Endangered Javan Leopard, one Critically Endangered and one Endangered bird, three migratory birds of prey, a restricted-range freshwater snail, and one internationally recognized area.

344. The overall significance of **potential impacts on Critical Habitat** is assessed as Low-Medium. There will be no clearance of Natural Habitat, and limited clearance of Modified Habitat. Likewise, most disturbance from construction and operations will take place in areas of Modified Habitat, away from most Critical Habitat-qualifying biodiversity. Impacts of vegetation loss and displacement of species owing to disturbance are thus assessed to be of Low significance. Impacts of water abstraction on the freshwater snail *Gyraulus terraesacrae* are very unclear, owing to insufficient data on its status and distribution, and on rates of water abstraction for the Project in relation to current stream flows.

345. The Dieng Mountains have been identified as an Important Bird Area (IBA), primarily owing to globally-significant concentrations of migratory birds of prey. The original project design involved a new 3 km power line. Should the area be important for these species, any power lines have the potential to cause direct mortality by collision –particularly during late afternoons when these birds descend to roost in trees in agricultural areas or along the forest edge, or mornings when they leave such areas. Such risks are exacerbated by regular cloudy/foggy conditions in the area. On a precautionary basis, given uncertainty but substantial potential risk, the potential impact of bird mortality from collision with power lines was considered of High significance.

346. The potential for indirect impacts has also been considered. As most Critical Habitat-qualifying biodiversity within the Project AoA is present in the forests of the Dieng Mountains rather than close to the Project area, hunting or trapping of wildlife by construction workers is considered to be of Low significance.

347. **Mitigation measures.** The BAP includes 3 specific mitigation and management measures necessary to reduce residual impacts on Critical Habitat-qualifying biodiversity to levels in line with the ADB Safeguard Policy Statement (ADB 2009). These are not anticipated to result in any significant Project time delays. These additional measures are:

- a. Ensure that **land clearance and sourcing of construction materials** do not take place within the IBA; sourcing of all construction materials such as wood, sand or gravel from Modified Habitat should be from outside of the IBA.

- b. **Bury power line underground** - the Project has decided to bury the planned power lines underground as a precaution that will completely avoid collision risks to migrating birds and demonstrate GDE world-leading best-practice.
- c. Ensure **sufficient flows** remain in any streams from which abstraction occurs. Based on further studies, GDE will ensure that water abstraction for drilling will only take place from surface water sources if sufficient water remains for agricultural use and ecological functionality.

348. **Residual impacts.** The BAP concludes that significant impacts on Natural Habitat are not anticipated, as the Project footprint falls entirely upon already Modified Habitat. The BAP further concludes that that with implementation of the above mitigation measures, no residual impact for Critical Habitat-qualifying (“priority”) biodiversity will remain greater than negligible.

5.3.8 Community and Occupational Safety Risks

Mobilization, well development, powerplant construction, and underground transmission line

349. Activities associated with well development and powerplant construction may pose occupational and community safety risks.

350. *Community safety* Mobilization of drilling equipment and material may cause significant concern to the communities in Karang Tengah, Sikunang, Kepakisan and Dieng Kulon given the type and condition of some of the stretches of public road. Pre-construction survey of the main transportation routes will be conducted to assess if adequate corridor or space is available, load capacity of bridges, the condition of the public roads including the buildings and/or houses located close to the roads (~ 100 m) to serve as baseline for road rehabilitation and property damages (if any). The PMU staff will join in the assessment of vehicle and rig movement to the project site. Each contractor will be required to prepare a traffic management plan to be approved by the PMU to ensure community safety. During mobilization, clear and visible traffic warning signs will be installed accommodating the requirements of children, elderly, and persons with disabilities. A designated staff from the contractor will be assigned continuously during construction works to manage traffic and to ensure public safety. Temporary crossing points will be provided accommodating children, elderly, and persons with disabilities.

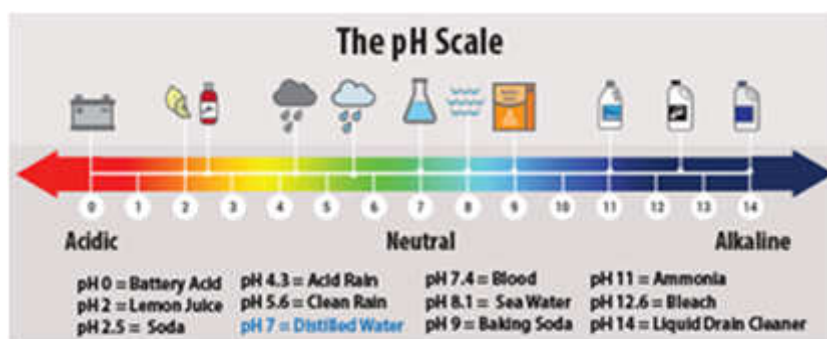
351. As discussed in Section 5.3.1, H₂S emissions during well drilling and venting can be a hazard that could affect community health and safety if present in high concentration. Detailed calculations and dispersion modeling showed that such risk is not significant. GDE has developed SOPs to further mitigate such potential H₂S risks to communities. Responsibilities are also passed down to the drilling contractors who will be required to monitor H₂S concentrations.

352. *Project perceptions* Local residents in the six villages within the project area are generally supportive as they view it as national development project and opportunities for employment and small-scale businesses. They have experienced the benefits of GDE's corporate social responsibility efforts. However, since Unit 1 was constructed several years ago, local residents may no longer have the memory of the construction phase. This may partly give rise to concerns that are based on speculations and inaccurate information about the project. Public consultations conducted in March 2019 and September 2019 show that perceptions are partly negative, primarily with regard to noise, impact on water resources, and risk to community safety. These perceived risks have been partly assessed through the IEE process, such as noise (Section 5.3.2), impact on water resources (Section 5.3.3), risk of H₂S on people and crops

(Section 5.3.1). Mis-perceptions will be addressed by GDE through the communications strategy plan and the information, education, and communications (IEC) initiatives. GDE plans to establish an information center at Unit 2. GDE has already started the IEC initiative with “*Geothermal Goes to School*”.

347. *Perceptions of atmospheric corrosion* Local communities within the areas of Unit perceive that atmospheric corrosion affecting their housing structures is coming from GDE operations. With the operation of Unit 2, this perception may continue creating anxiety and uncertainties among the local residents.

348. Geothermal power generation does not generate nitrogen dioxide (NO₂) and sulfur dioxide (SO₂) the main causes of acid rain. A remarkable volcanic feature is shown by the Dieng Plateau in Central Java, which has “*kawah upas*” or the death valley due to the high concentration of CO₂. The CO₂ reacts with water in the atmosphere to form carbonic acid (H₂CO₃), a weak acid. The normal rain has a pH³⁵ of about 5.6; it is slightly acidic because of the carbonic acid (Figure 5.6). Dieng has about 2,700 mm of rainfall per year with rainy days of about 68% of the year (i.e., December in 2018 has 31 rainy days). The weak carbonic acid progressively attacks the roof and the structures every year with the heavy rainfall eight months of the year in Dieng. GDE will continue consultations with the communities to explore opportunities for assistance.



Source: US Environmental Protection Agency. pH of common substance.
<https://www.epa.gov/sites/production/files/2015-10/documents/1622624.pdf>

Figure 5.6: pH of Common Substances

353. *Occupational health and safety* Construction works pose occupational health and safety risks. During well testing, potential health hazards come from noise and H₂S emissions (Table 5.8 and Table 5.9). Workers assign to these works will be provided with PPE. The use of SCBA's and portable H₂S level monitors by workers in the immediate area of well testing will be required. Regular calibration of monitoring equipment will be done to assure accuracy of readings. Safety and medical personnel will be available on-site. Seminars on occupational safety and health hazards will be conducted prior to construction works. Daily toolbox meetings daily will be conducted by the Site Engineers or the staff responsible to the construction site. This daily 5-10 minute talk will be opportunities to emphasize safety and health procedures relevant to the nature and location of work that will be completed for the day.

³⁵ pH is a measure of the acidity and alkalinity of a substance. A pH of 7.0 is neutral. The lower the pH of a substance (less than 7), the more acidic it is; the higher the pH of a substance (greater than 7), the more alkaline it is.

354. The contractor will provide sanitary facilities and safe drinking water at the construction site and at the workers' camp. Workers will be provided with PPEs such as goggles, safety shoes, etc. and its use will be mandatory. Workers who will be assigned to high level noise-generating works will be rotated every two hours aside from wearing of PPEs.

355. Site Engineers or staff responsible to the construction site will encourage brief exercise routine to highlight the value of health in the workplace. Contractors will provide health and accident insurance as well as free physical and medical examination for their workers. Health records will be kept confidential in the employee file.

356. Clear and visible warning signs will be installed, and sufficient lighting will be provided to minimize accidents. Contractors will be required to follow relevant HSE SOPs of GDE and relevant IFC-EHS General Guidelines 2007 particularly Section 2.

Powerplant operation

357. GDE's EHS Manual including Standard Operating Procedures (SOPs), is comprehensive (see Section 4.6 and Appendix 7) and personnel are provided with training on health and safety issues at a level appropriate to the specific risks associated with their job description. Though job related accidents may still happen, the policies and SOPs in place will effectively reduce the risks and occurrence. Nearby communities will be invited to participate in the emergency drills. They will be continually engaged on living safely close to a geothermal power plant.

358. Given the technology chosen for unit 2, a potential safety concern is the organic fluid storage tank within Unit 2 (the power plant will require butane and isopentane during operation). These substances are flammable and will require special handling and storage to minimize the risk of explosion. A safety risk assessment was conducted for Unit 2, confirming that additional safety measures (i.e. blast wall) will be required as part of the project design (see chapter 5.4).

Installation of underground transmission line

359. The installation, connection, and closure of the underground transmission lines (UGTL) from Unit 2 to the existing substation in Unit 1 may also cause generation of dust, noise, wastes, and occupational health and safety risks within about 6.9 km stretch of the route. These activities will include stripping of vegetation, excavation, electrical, mechanical and other civil works. As a result, local residents may experience temporary disruptions of their daily activities. Heavy equipment such as backhoe will dig the trench for the pipeline. Topsoil will be re-used to backfill the trench. Once the construction activities for the UGTL are completed, the route affected will be restored to their original condition and topography. Appropriate measures to minimize dust, noise, use of PPEs, traffic management, etc. will be similarly implemented by contractors.

360. Only some herbal vegetation and agricultural crops may be allowed to return to the ROW for safety. Appropriate visible and clear markers and warning signs will be installed along the UGTL to alert local residents of the location and what is underneath. Markers will be painted with reflective paints for visibility at night and foggy days in Dieng.

5.3.9 Greenhouse Gas (GHG) Emissions

361. Geothermal is a low-GHG emission option that is renewable. Though coal, gas and diesel tend to be the most commercially viable in Indonesia, geothermal energy is widely available in

These activities may cause potential impacts such as generation of waste/debris, increased dust, noise level and vibration; traffic congestion, and occupational health and community safety risks.

364. In the event decommissioning will happen during well development when it is proven not economical for power generation, the following will be undertaken:

- (i) the sump that was used during well development will be backfilled with previously stripped topsoil which is kept reserved;
- (ii) revegetation will be done after backfilling;
- (iii) the well pad will be capped, secured, and maintained for monitoring purposes;
- (iv) if keeping the well will be unsafe to maintain, it will be cemented and plugged and the well assembly stripped;
- (v) Other wastes generated such as empty cement sacks and other debris, it will be collected and disposed of in designated disposal sites in Dieng;
- (vi) Reusable items like excess cement, drilling materials, etc. will be stored in a warehouse in Unit 2;
- (vii) Other support infrastructure like water supply and brine transport, these will be disconnected and hauled out of the well pad and reused in other GDE projects.

365. If decommissioning will be at the end of economic life of Unit 2 which is expected to be 30 years, an inventory will be done to determine the usability/recyclability of the equipment, machinery, and other assets. A decommissioning plan will be prepared following the EHS requirements of Indonesia. Consultations will be conducted to the communities of Karang Tengah, Kepakisan, Dieng Kulon, and Sikunang during the preparation of the decommissioning plan as closure may mean losing jobs, and to ensure that the same will be appropriate to the local land use plan and needs of the local communities. The decommissioning plan will cover measures to restore the site to as close as practicable to its pre-development condition and will depend on the intended use of the area and the reusability of existing facilities to other GDE facilities by that time. Suitability of buildings and equipment will be assessed for other projects, or donated to the community, if found useful. Those not considered reusable will be disposed of properly and safely based on the decommissioning plan. The site will be revegetated and/or rehabilitated with appropriate species of terrestrial flora suitable to the location.

5.3.11 Cumulative Impacts

366. The Canadian Environmental Assessment Agency provides a simple definition of cumulative impacts as, "cumulative effects are changes to the environment that are caused by an action in combination with other past, present, and future human actions."

367. Based on this definition, the potential cumulative impacts of Unit 1, Unit 2 and Unit 3 (planned) were evaluated based on available environmental monitoring data and the preliminary results of modeling.

Air Quality

368. As required by the MOE Regulation No. 21/2008, six sampling points are being monitored by GDE for H₂S emissions in Dieng Unit 1. This is being monitored quarterly by a 3rd party MOEF-accredited monitoring firm engaged by GDE. The monitoring results are included in the RPL submitted to the MOEF. Data show that Unit 1 complies to the limit of 35 mg/Nm³ (now 30

mg/Nm³). Similarly, the ambient air quality is also being monitored quarterly as required by MOE Decree No. 50/1996). Ambient monitoring data show that it generally meet the H₂S limit for odour of 0.02 ppm. The monitoring results for both the emission and ambient air quality are submitted to the MOEF as RPL.

369. Based on the available operating data at this stage, the results of air quality dispersion modeling show that the highest ground level concentration (GLC) of H₂S is 372 µg/m³. This H₂S GLC will occur at about 150 m northeast of the cooling tower. Given that this receptor is within the power plant, the limit at this receptor is 1,400 µg/m³ (8-hour averaging time) for working environment based on the Regulation of the Minister of Employment and Transmigration Number PER.13/MEN/X/2011. Air quality dispersion modeling will be conducted again once the FEED and detailed engineering design are completed to determine compliance.

Noise

370. Similar to air quality, noise levels are also being monitored by GDE. Results of monitoring show that Unit 1 is generally in compliance to the limits set by MOE decree No. 48/1996 on noise. Noise assessment study was conducted for Unit 2 and Unit 3, with several scenarios which included the combined operation of Unit 1, Unit 2 and Unit 3. Noise modeling results show that operating all 3 units will meet the limits of IFC-WB EHS General Guidelines 2007 and the Indonesia noise limits. The noise assessment study will be repeated during the detailed engineering design once more details are available. Results will be disclosed to the public.

5.4 Safety Risk Assessment for existing and proposed facilities

371. In the framework of this IEE, a comprehensive risk assessment for existing and proposed facilities in Dieng was conducted by an independent consultant³⁹ following an internationally accepted risk assessment methodology: Hazard Identification (HAZID) for qualitative risk assessment and ALOHA⁴⁰ Simulation and Monte Carlo Simulation for Quantitative Risk Assessment.

372. The main purpose of the assignment was to identify and rate risks of the existing (Unit 1) and proposed (Unit 2) facilities, focusing on (a) well production and well injection system, (b) pipeline gathering system and (c) power plant system. The assessment also looked at GDE's response to identified risks and residual risks with those measures, and recommended additional measures to mitigate residual risks to acceptable levels. The full risk assessment is documented in Appendix 8. The following sections summarize the key findings of the assessment and recommended risk mitigation measures.

5.4.1 Methodology

373. The risk assessment was guided by ISO/IEC 31010 standard (Guidance on risk assessment techniques selection). The risk assessment was conducted in two phases, including a qualitative and a quantitative risk assessment. Considering availability of data and the stage of project preparation (feasibility study), HAZID (Hazard Identification) was used as qualitative risk

³⁹ IJK Consultancy

⁴⁰ ALOHA® is the hazard modeling program for the CAMEO® software suite, which is used widely to plan for and respond to chemical emergencies.

assessment technique. ALOHA and Monte Carlo simulation were used to quantify those risks considered extremely high risk.

374. The methodology adopted in this HAZID study followed EN ISO 17776:2002⁴¹ as an established good practice. A hazard list was developed from the guidance provided in ISO 17776:2002 Annex D, and based on site observations, discussions with GDE staff and document review. The steps of HAZID included:

- a. Develop a list of credible risks/scenarios from the hazard list provided in ISO 17776:2002 Annex D;
- b. Qualitatively determine the 'worst case' consequences and likelihood of a risk, assuming no mitigation;
- c. Assign an unmitigated risk category (Low, Medium, High, Extremely High);
- d. For those scenarios with an unmitigated risk of High or Medium, identify existing mitigations as implemented by GDE (for Unit 1) or as proposed by GDE and/or as defined in FS (for Unit 2) that either reduce the likelihood of the risk, or limit its consequences;
- e. Qualitatively determine the consequences and likelihood, assuming existing/proposed mitigation;
- f. Use the risk matrix to assign a mitigated risk category (Low, Medium, High, Extremely High);
- g. For those scenarios with a mitigated risk of High or Medium identify recommendations to achieve further risk reduction.

375. Determination of risks, their probability (likelihood), and their impact (consequence) were based on site visits, questionnaire to the GDE employee, and professional judgment. The following rating system was applied (Table 5.13, Table 5.14, Figure 5.7).

Table 5.13: Ranking of risks based on consequence of impact

Consequence Rank	Decision Issue			
	Impact on People	Environment Impact	Operational / Financial Impact	Reputation Impact, Social Impact
1 (Slight)	Slight Injury or Illness ; First aid case	Slight effect; environmental impact could last for days; no long term consequences; spill or release internal to facility	Slight Damage; no significant impact on operations; no loss in revenue	Slight Impact; no impact to local community; little notice by community
2 (Minor)	Minor Injury or Illness ' OSHA recordable/ Doctor Visit	Minor effect; environmental impact could last for weeks; spill or release external to facility no cleanup required	Minor Damage; damage to equipment; minor impact on operations; no loss in revenue	Minor impact; immediate area to facility may be alerted; odor or noise complaints

⁴¹ Petroleum and natural gas industries – Offshore production installations – Guidelines on tools and techniques for hazard identification and risk assessment.

3 (Severe)	Severe Injury or Illness / Lost Time	Severe effect; environmental impact could last for months; reportable quantity spill or release requires cleanup	Local Damage; severe damage to equipment; impact on part of operations; partial loss of revenue	Considerable impact to local community; potential acute health impacts to community; Community response plan activated
4 (Major)	Potential fatalities or permanent disabling Injury or Illness	Major effect; environmental impact could last for years; area becomes restricted for a limited period of time	Major Damage; major damage to equipment; delay in operations; short term loss in revenue	Impact would receive regional and industry coverage; potential chronic health impact to community
5 (Catastrophic)	Potential multiple fatalities or permanent disabling Injury or Illness	Massive effect; environmental impact could last for decades; long term contamination requiring remediation	Extensive Damage; long term impact on operations; long term loss in revenue	Impact would receive national and global attention

Note: adapted from Appendix E of AS/NZS 4360-1999

Table 5.14: Ranking of risks based on likelihood of impact

Likelihood Rank	Description	
E	Almost certain	Occurs more than once per month
D	Likely	Occurs once every 1 month - 1 year
C	Possible	Occurs once every 1 year - 10 years
B	Unlikely	Occurs once every 10 years - 100 years
A	Rare	Occurs less than once every 100 years

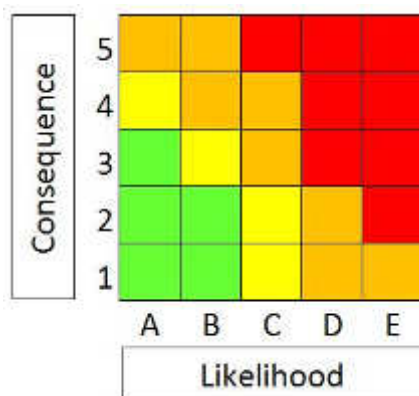


Figure 5.7: Risk Matrix

Note: Green – Low; Yellow – Medium; Orange – High; Red – Extremely High

376. The second phase, the quantitative risk assessment, consisted of two sub-studies, including (i) ALOHA simulation to estimate the flammable explosion threat zone, and (ii) Monte Carlo simulation to quantify (in monetary terms) those that relate to EHS that impact environment and community.

5.4.2 HAZID Findings


377. The HAZID was conducted for the existing facilities (Unit 1, covering well pads, steam gathering system, and power plant) as well as for the proposed Unit 2 (covering both construction and operation).

378. A total of 330 risks/scenarios were assessed, and risks without mitigation were classified in extremely high risk (36); high risk (222); medium risk (72) and low risk (0). Risk mitigation measures as implemented by GDE either through physical interventions or through safety procedures (standard operating procedures, safety manuals, trainings etc.) are able to significantly reduce risk levels, including extremely high risk (reduced from 36 to 6); high risk (reduced from 222 to 126); medium risk (increased from 72 to 136) and low risk (increased from 0 to 62). The residual extremely high risks that may affect community health and safety or the environment primarily relate to the following scenarios:

- h. Unit 1 & 2 Production Well: Brine pond at well pad 10 overflow, leading to damage of ground water, damage of planting and landslide.
- i. Unit 1 & 2 Production Well: H₂S emissions dispersed from silencer, which could affect nearby communities (primarily bad odors, but H₂S could be dangerous as it denser than air; and thus could accumulate in depressions).
- j. Unit 2 Power Plant, organic fluid storage: Malfunction of control system and safety device leading to rupture of organic fluid storage (Butane and Pentane), potentially resulting in explosion and injury of workers and nearby residential area at Karang Tengah Village.

379. Table 5.15 provides an overview of the identified hazards, their risk categorization without mitigation measures (worst case scenario), and with mitigation measure as currently implemented (Unit 1) or proposed (as per FS) by GDE. Recommended additional measures are listed in column 4, as needed.

Table 5.15: Identified risks without (left) and with (right) mitigation measures, Operation Phase


Hazard	Description (scenario)	Risk category (without mitigation measure)	Key risk mitigation measures by GDE (actual or proposed); key identified gaps (additional measures)	Risk category (with mitigation measures)
Unit 1 and Unit 2 Production Phase (existing facilities)				
01. Pressure/Explosive Hazard				
Geothermal Fluid at High Pressure	<p>Corrosion leading to pipe and wellhead leakage and rupture (see in 04. Corrosive Substances Hazard for detail).</p> <p><i>Location:</i></p> <p>a. Unit 1: Well pad 7, 28, 29, 30, and 31.</p> <p>b. Unit 2: Well pad 7, 9, 10, 30, 31</p>	5C (E)	<ul style="list-style-type: none"> SOP Wellhead Operation SOP Pipe Rupture (GDE-DIENG-HSE-SOP-022-R1) SOP of PPE (GDE-DIENG-HSE-SOP-012) SOP of First aid (GDE-DIENG-HSE-SOP-048) Design and install casing/tubing properly Intensive wall thickness inspection Develop SOP for Pipe Rupture for Unit 2 Expand EP&R to Unit 2 facilities <p>Recommended Additional Measures:</p> <ul style="list-style-type: none"> Install visible warning signs for all personnel (Well pad 30). Remove the unused tank. 	5B (H)


Hazard	Description (scenario)	Risk category (without mitigation measure)	Key risk mitigation measures by GDE (actual or proposed); key identified gaps (additional measures)	Risk category (with mitigation measures)
	<p>Casing burst or tubing collapse due to well fluid pressure and temperature.</p> <p><i>Location:</i></p> <p>a. Unit 1: Well pad 7, 28, 29, 30, and 31.</p> <p>b. Unit 2: Well pad 7, 9, 10, 30, 31</p>	4C (H)	<ul style="list-style-type: none"> Design and install casing/tubing properly Use burst discs to ensure that the outer casing fails (bursts) before casing or tubing collapse. SOP of Emergency Preparedness and Response (GDE-DIENG-HSE-SOP-014) Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) Expand EP&R to Unit 2 facilities. 	4B (H)
	<p>Operator does not comply with operation and HSE SOP leading to damage to pipes and equipment rupture. Complaints from community.</p> <p><i>Location:</i></p> <p>a. Unit 1: Well pad & Injection 5, 7, 15, 28, 29, 30, and 31, Gathering System, Power Plant.</p> <p>b. Unit 2: Well pad 7, 9, 10, 30, 31 Gathering System, Power Plant.</p>	5C (E)	<ul style="list-style-type: none"> Training of procedure and HSE SOP SOP of Contractor Safety Management System (GDE-DIENG-HSE-SOP-051) SOP of Job Safety Analysis (GDE-DIENG-HSE-SOP-042) SOP of Permit to Work (GDE-DIENG-HSE-SOP-034) & SOP of Lock Out Tag Out (GDE-DIENG-HSE-SOP-047) PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) Stand By SCBA of EPR Team H₂S Detector First Aid 	5A (H)
	<p>Condensate carries over leading to abrasive to pipeline leading to pipe rupture.</p> <p><i>Location:</i></p> <p>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Gathering System, Power Plant.</p> <p>b. Unit 2: Well pad 7, 9, 10, 30, 31 Gathering System, Power Plant.</p>	5A (H)	<ul style="list-style-type: none"> Install steam trap Rock muffler Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) 	5A (H)
	<p>Malfunction of control system and safety device leading to rupture at storage Tank of Organic Fluid (Butane and Pentane) rupture. Potentially explosion, injury of people.</p> <p><i>Location:</i></p> <p>a. Unit 2: Power Plant</p>	5C (E)	<p>Recommended Additional measures:</p> <ul style="list-style-type: none"> Conduct detailed risk assessment as part of DED Design and install Blast Wall 	5C (E)
02. Object Under Induced Stress				
Object Under Compression	<p>Pressure Safety Valve blocked leading to explosion, worker injury, downtime, noise to the community, damage to assets, and also affected to company reputation.</p> <p><i>Location:</i></p> <p>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Power Plant.</p> <p>b. Unit 2: Well pad 7, 9, 10, 30, 31 Power Plant.</p>	4B (H)	<ul style="list-style-type: none"> Pressure Safety Valve certification by qualified institution Regular Pressure Safety Valve inspection/monitoring Rupture Disk Alarm System, Shut Down System SOP of Emergency Preparedness and Response (GDE-DIENG-HSE-SOP-014) Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) 	4A (M)

Hazard	Description (scenario)	Risk category (without mitigation measure)	Key risk mitigation measures by GDE (actual or proposed); key identified gaps (additional measures)	Risk category (with mitigation measures)
			<ul style="list-style-type: none"> First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) 	
03. Dynamic Situation Hazard				
Brine Booster Pump	<p>Pump being out of balance (due to erosion, corrosion, seal failure, scaling) could lead to over flow in the pond. Potentially contaminate the ground water nearby the area and damage the plantation.</p> <p><i>Location:</i> <i>a. Unit 1: Well pad 7, 29, 30</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31</i></p>	3C (H)	<ul style="list-style-type: none"> Appropriate selection of pump based on standard Preventive Maintenance System Flow Valve Close Back Up Pump starts running 	3B (M)
Acid Feed Pump (X-156A&B, X-159A&B, X-160)	<p>Pump being out of balance (due to erosion, seal failure) could give rise to vibration, and overheat leading to failure of acidification.</p> <p><i>Location:</i> <i>a. Unit 1: Well pad 7, 29, 30</i> <i>Unit 2: Well pad 7, 9, 10, 30, 31</i></p>	3C (H)	<ul style="list-style-type: none"> Appropriate selection of pump based on standard Preventive Maintenance System Basic Process Control System Back Up Pump starts running Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) 	3B (M)
Wellhead Collision by vehicles	<p>Drive without following predetermined rules/ lack of maneuvering room, leading to damages to pipe, resulting injury, leakage of pipe fluid and explosion.</p> <p><i>Location:</i> <i>a. Unit 1: Well pad & injection 7, 28, 29, 30, and 31.</i> <i>Unit 2: Well pad 7, 9, 10, 30, 31</i></p>	3B (M)	<ul style="list-style-type: none"> Install Warning Signs SOP of Pipe Rupture (GDE-DIENG-HSE-SOP-022-R1) SOP of Driving Vehicle (GDE-DIENG-HSE-SOP-023-R1) SOP of Parking Management (GDE-DIENG-HSE-SOP-024-R1) Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) 	3A (L)
Gathering Pipeline Collision by vehicles	<p>Drive without following predetermined rules/ lack of maneuvering room, leading to damages to pipe, resulting injury, leakage of pipe fluid and explosion.</p> <p><i>Location:</i> <i>b. Unit 1: Gathering Pipeline.</i> <i>c. Unit 2: Gathering Pipeline.</i></p>	3C (H)	<ul style="list-style-type: none"> Install Warning Signs SOP of Pipe Rupture (GDE-DIENG-HSE-SOP-022-R1) SOP of Driving Vehicle (GDE-DIENG-HSE-SOP-023-R1) SOP of Parking Management (GDE-DIENG-HSE-SOP-024-R1) Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) 	3B (M)
04. Corrosive Substances Hazard				
Brine	<p>Brine pipe is stuck due to scaling formed in the internal pipe surface leading to pond overflow and eventually contaminate to the subsurface water. (contaminate environment)</p> <p><i>Location:</i></p>	4E (E)	<ul style="list-style-type: none"> Equipment design and material selection Regular inspections and maintenance of ponds 	4B (H)

Hazard	Description (scenario)	Risk category (without mitigation measure)	Key risk mitigation measures by GDE (actual or proposed); key identified gaps (additional measures)	Risk category (with mitigation measures)
	<p>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Power Plant.</p> <p>b. Unit 2: Well pad 7, 9, 10, 30, 31 Power Plant.</p>			
H ₂ S	<p>Sufficient H₂S causes sour corrosion and Sulphide Stress Cracking in high strength steel, leading to leak and potential rupture of well equipment. H₂S exposed to the wet atmosphere (humid) potentially promote severe corrosion on the metal steel roofing of community house.</p> <p><i>Location:</i></p> <p>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Power Plant.</p> <p>b. Unit 2: Well pad 7, 9, 10, 30, 31, Power Plant.</p>	4D (E)	<ul style="list-style-type: none"> Corrosion Allowance Inspection techniques for surface equipment Monitoring water analyses (pH, Fe²⁺, etc.) Utilization of coating or corrosion resistance alloys (CRA) for equipment 	4C (H)
CO ₂	<p>Lowering the pH and in sufficient quantities of CO₂ may promote general corrosion and / or pitting corrosion, leading to leak and potential rupture of well equipment. CO₂ exposed to the humid air causes acid containing atmosphere which potentially promote severe corrosion on the metal steel roofing of community house.</p> <p><i>Location:</i></p> <p>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Power Plant.</p> <p>b. Unit 2: Well pad 7, 9, 10, 30, 31, Power Plant.</p>	4B (H)	<ul style="list-style-type: none"> Regular Inspections Preventive Maintenance Acidification Monitoring Chemical Dosing 	4B (H)
Chloride (Cl)	<p>Enhanced corrosion (general, pitting corrosion and stress corrosion cracking) of well equipment leading to leak and rupture. Cl exposed to the humid air causes acid containing atmosphere which potentially promote severe corrosion on the metal steel roofing of community house.</p> <p><i>Location:</i></p> <p>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Power Plant.</p> <p>b. Unit 2: Well pad 7, 9, 10, 30, 31, Power Plant.</p>	4B (H)	<ul style="list-style-type: none"> Corrosion Allowance Application of corrosion inhibitors for carbon steel Corrosion monitoring Inspection techniques for surface equipment Monitoring water analyses (pH, Fe²⁺, etc.) Utilization of coating or corrosion resistance alloys (CRA) for equipment 	4A (M)

Hazard	Description (scenario)	Risk category (without mitigation measure)	Key risk mitigation measures by GDE (actual or proposed); key identified gaps (additional measures)	Risk category (with mitigation measures)
Descaling Chemical (Acidification)	<p>Corrosion and potential damage to the well equipment and surface equipment if incorrect concentration and type. Corrosion leading to leak and damage of well equipment. Brine and gases release to the atmosphere and contaminate promote severe corrosion on the metal steel roofing of community house.</p> <p><i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31</i></p>	4B (H)	<ul style="list-style-type: none"> • Proper Operating Procedures • Training and awareness of personnel • Monitoring Chemical Dosing 	4B (H)
Dissolved Solids and Chemical	<p>Precipitated sand cause erosion particularly most severe in wellhead, surface equipment and subsurface pumps, blockage of flow, incomplete scaling can lead to Under Deposit Corrosion leading to leak and damage of well equipment. Brine and gases release to the atmosphere and contaminate promote severe corrosion on the metal steel roofing of community house.</p> <p><i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31.</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31.</i></p>	4C (H)	<ul style="list-style-type: none"> • Proper design of the geothermal plant and selection of operating • pH adjustment • Use of chemical additives (inhibitors or acidification) • The removal of deposits by chemical or mechanical means • Prevent production of solids for example sand-screens in the well • Biocides or disinfectants may be added to the fluids to prevent microbiologically catalyzed mineral precipitation • Used “hard-facing” of critical locations such as components in flow control (choke) valves or in pumps 	4B (H)
Water Borne Bacteria	<p><i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31.</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31.</i></p> <ul style="list-style-type: none"> • Potential for microbiologically influenced corrosion mostly on shut-in wells (particularly water injector), outer annulus spaces and external side of casing leading to leakage and contaminate the surrounding subsurface water. 	4B (H)	<ul style="list-style-type: none"> • Continuous application of biocides combined with chemical cleaning (descaling). • Maintain flow velocities above minimum levels will control micro-organisms. • The presence of micro-organisms can be monitored by sampling and laboratory analysis (MPN – most probable number method) 	4A (M)
External aggressive aquifers	<p>External corrosion attack of casing leading to budding and well collapse leading to leakage and contaminate the surrounding subsurface water.</p> <p><i>Location:</i></p>	4B (H)	<ul style="list-style-type: none"> • Cement design to ensure casing protection • Application of cathodic protection for casing. 	4B (H)

Hazard	Description (scenario)	Risk category (without mitigation measure)	Key risk mitigation measures by GDE (actual or proposed); key identified gaps (additional measures)	Risk category (with mitigation measures)
	<i>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Power Plant.</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31, Power Plant.</i>			
05. Hot Surfaces				
Process piping	Direct contact leading to personal injury and / or asset damage <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Gathering System, Power Plant.</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31, Gathering System, Power Plant.</i>	3B (M)	<ul style="list-style-type: none"> Insulation pipe/ surface equipment SOP operation, including inspection protocol Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) <p>Recommended additional measures:</p> <ul style="list-style-type: none"> Repair damaged insulation on the loop pipeline in gathering system, especially at location near volcanology Research Center and well pad 9. 	3A (L)
06. Electricity				
Short Circuit	Short Circuit leading to fire and explosion. <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Gathering System, Power Plant.</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31, Gathering System, Power Plant.</i>	5A (H)	<ul style="list-style-type: none"> Proper electricity installation based on oil & gas standard. SOP of Fire Handling (GDE-DIENG-HSE-SOP-020-R1) Fire System (P&ID 20262-05-32162) Fire Hydrant/Extinguisher, Sprinkler system Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) 	5A (H)
07. Toxic Gas				
H ₂ S Exposure	Potential to accumulate in cellar as it is denser than air. Leading to health damage of personnel. <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31</i>	5E (E)	<ul style="list-style-type: none"> Worker Safety Training H₂S Detector H₂S Monitoring Adequate ventilation of occupied building SOP of Toxic Gas Handling (GDE-DIENG-HSE-SOP-017-R1) SCBA for ERT Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) Develop SOP of toxic gas handling of Unit 2. 	5B (H)

Hazard	Description (scenario)	Risk category (without mitigation measure)	Key risk mitigation measures by GDE (actual or proposed); key identified gaps (additional measures)	Risk category (with mitigation measures)
	Nearby communities exposed to H ₂ S from silencer, causing eye irritation, bad odor and headache. <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31</i> <i>b. Unit 2: Sensitive Receptors</i>	3D (E)	<ul style="list-style-type: none"> SOP of Toxic Gas Handling (GDE-DIENG-HSE-SOP-017-R1) Develop SOP for Toxic Gas Handling for Unit 2. <p>Recommended additional measures:</p> <ul style="list-style-type: none"> Community counseling/simulation to handling H₂S exposure by GDE Peduli (CSR) or third party. 	3D (E)
08. Toxic Fluid				
Brine	Brine in the pond overflow, leading to damage of ground water, damage of farmland <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31</i>	3D (E)	<ul style="list-style-type: none"> Sand sack used as dike for the overflow brine. <p>Recommended additional measures</p> <ul style="list-style-type: none"> Pond dimension is not proper to accommodate brine (Well pad 30 and Well Pad 10) 	3D (E)
09. Refined Hydrocarbon				
Diesel Leakage	Diesel Fuel Pipe/Storage leakage or spill leading to health impact to the worker, contamination to the environment. <i>Location:</i> <i>a. Unit 1: Power Plant.</i> <i>b. Unit 2: Power Plant.</i>	3C (H)	<ul style="list-style-type: none"> Proper Design of Emergency Diesel Generator SOP of hazardous material waste spill for Unit 1 (GDE-DIENG-HSE-SOP-040-R1) Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) Develop SOP of hazardous material waste spill of Unit 2. 	3B (M)
Lube Oil Spill	Lube oil Pipe/ Storage leakage or spill leading to health damage to the worker, contamination to the environment. <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Power Plant.</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31, Power Plant.</i>	3C (H)	<ul style="list-style-type: none"> SOP of hazardous material waste spill (GDE-DIENG-HSE-SOP-040-R1) Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) 	3B (M)
12. Environmental Hazards				
Non Hazardous Waste	Stacked Pipe <i>Location:</i> <i>Unit 1: Well pad 7</i>	2C (M)	<ul style="list-style-type: none"> SOP of Non Hazardous Material Waste Handling (GDE-DIENG-HSE-SOP-038-R1) <p>Identified Gaps:</p> <ul style="list-style-type: none"> Make a specific backfill to stack the pipe. Pipe positions have to be aligning with ground. 	2B (L)

Hazard	Description (scenario)	Risk category (without mitigation measure)	Key risk mitigation measures by GDE (actual or proposed); key identified gaps (additional measures)	Risk category (with mitigation measures)
	Garbage from general activities. <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Gathering System, Power Plant.</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31, Gathering System, Power Plant.</i>	2C (M)	<ul style="list-style-type: none"> SOP of Non Hazardous Material Waste Handling (GDE-DIENG-HSE-SOP-038-R1) 	2B (L)
Hazardous Substance Waste	Silica Compounds around the pond and scaling pipe. <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31</i>	3C (H)	<ul style="list-style-type: none"> Collected in the pond side. <p>Recommended additional measures:</p> <ul style="list-style-type: none"> Make specific place for collected silica from all well pad (Unit 7, Unit 28 and Unit 30) GDE had SOP for hazardous material waste management, but this SOP does not cover silica. Recommend to elaborate about silica waste management. 	3B (M)
	Hazardous chemical container <i>Location:</i> <i>a. Unit 1: Power Plant.</i> <i>b. Unit 2: Power Plant.</i>	3C (H)	<ul style="list-style-type: none"> SOP of Hazardous Material Waste Handling (GDE-DIENG-HSE-SOP-037-R1) 	3B (M)
Geological Hazard	Earthquake <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Gathering System, Power Plant.</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31, Gathering System, Power Plant.</i>	5B (H)	<ul style="list-style-type: none"> Emergency Drill with worker SOP of Earthquake Evacuation (GDE-DIENG-HSE-SOP-015-R1) 	5B (H)
	Landslide <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Gathering System, Power Plant.</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31, Gathering System, Power Plant.</i>	4D (E)	<ul style="list-style-type: none"> Emergency Drill (early warning system) with worker and community (in Ds. Pranten at 21 June 2019) SOP of Landslides (GDE-DIENG-HSE-SOP-018-R1) 	2D (H)
13. Noise				

Hazard	Description (scenario)	Risk category (without mitigation measure)	Key risk mitigation measures by GDE (actual or proposed); key identified gaps (additional measures)	Risk category (with mitigation measures)
Noise Pollution	<p>When separator drain the brine to Atmospheric Flash Tank, resulting noise due to reducing brine pressure in separator to atmospheric pressure leading to noisy sound that arise complaints from neighbors.</p> <p><i>Location:</i> a. Unit 1: Well pad 7, 28, 29, 30, and 31. b. Unit 2: Well pad 7, 9, 10, 30, 31.</p>	3C (H)	<ul style="list-style-type: none"> Regular noise monitoring as per approved monitoring plan Unit 2 will apply international good practice for noise control <p>Recommended additional measures:</p> <ul style="list-style-type: none"> Establish and maintain grievance redress mechanism (GRM) Sharing information to nearby community. 	3C (H)
	<p>Steam Purifier Vent noise potential to hearing damage of personnel</p> <p><i>Location:</i> a. Unit 1: Power Plant. b. Unit 2: Power Plant.</p>	2D (H)	<ul style="list-style-type: none"> Proper structure design of cooling tower Warning Sign SOP of Turbine / generator operation/maintenance Regular noise monitoring Steam Vent Silencer Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) First Aid kits at site as SOP of First aid (GDE-DIENG-HSE-SOP-048) <p>Recommended Additional measures:</p> <ul style="list-style-type: none"> EPC contractor to conduct detailed noise modeling to confirm compliance with relevant noise standard (55dB/45dB day-time and night-time noise at nearest sensitive receptor) 	2B (L)
	<p>Geothermal fluid pressure is above the set limit during operation, start up, shut down or trip and exceeded to the vent causing hearing damage of personnel and nearby community</p> <p><i>Location:</i> a. Unit 1: Well pad 7, 28, 29, 30, and 31. b. Unit 2: Well pad 7, 9, 10, 30, and 31.</p>	2C (M)	<ul style="list-style-type: none"> Proper process flow design to anticipate overpressure Rock Muffler Provide PPE (helmet, safety boots) as SOP of PPE (GDE-DIENG-HSE-SOP-012) 	2B (L)
14. Use of Natural Resources				
Water	<p>Water use for condenser is not injected back to the ground leading to depleting of water resources and unbalance ecology system.</p> <p><i>Location:</i> a. Unit 1: Power Plant. b. Unit 2: Power Plant.</p>	4B (H)	<ul style="list-style-type: none"> By-Pass to blow down pump to be injected back to the ground SOP of Nature Source Management (GDE-DIENG-HSE-SOP-041) 	4A (M)
15. Security Related Hazard				

Hazard	Description (scenario)	Risk category (without mitigation measure)	Key risk mitigation measures by GDE (actual or proposed); key identified gaps (additional measures)	Risk category (with mitigation measures)
Mass Demonstration	Operational activities give negative impact to the community leading to bad reputation and social impact. <i>Location:</i> <i>a. Unit 1: Power Plant.</i> <i>b. Unit 2: Power Plant.</i>	4D (E)	<ul style="list-style-type: none"> Security risk assessment, Security control at the site entrance and around the site. Fencing around drill site, Crew awareness SOP of Farmer Claim Handling (GDE-DIENG-HSE-SOP-039) SOP of Mass Demonstration Handling (GDE-DIENG-HSE-SOP-050) 	4B (H)
Intruders	Sabotage causing fire or loss production potential to personal injury, downtime, damage to asset, reputation, and social impact <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Gathering System, Power Plant.</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31, Gathering System, Power Plant.</i>	2D (H)	<ul style="list-style-type: none"> Security risk assessment Fencing around well pads, continuous security control at most pads Crew awareness Disciplinary Procedures SOP of Limitation of Entry Permit (GDE-DIENG-HSE-SOP-046) <p>Recommended additional measures:</p> <ul style="list-style-type: none"> Improve access control to existing well pads 9, 29 and 30 including fencing, gate and security guard. 	2B (L)
	Theft causing loss asset potential to personal injury, downtime, damage to asset, reputation, and social impact <i>Location:</i> <i>a. Unit 1: Well pad 7, 28, 29, 30, and 31, Gathering System, Power Plant.</i> <i>b. Unit 2: Well pad 7, 9, 10, 30, 31, 38, Gathering System, Power Plant.</i>	2D (H)	<ul style="list-style-type: none"> Security risk assessment Security control at the site entrance and around the site. Fencing around well pads site Crew awareness SOP of Emergency Preparedness and Response (GDE-DIENG-HSE-SOP-014) SOP of Limitation of Entry Permit (GDE-DIENG-HSE-SOP-046) <p>Recommended additional measures:</p> <ul style="list-style-type: none"> Improve access control to all existing well pads most importantly well pads 9, 29 and 30 including fencing, gate and security guard. 	2B (L)

380. Additional measures as recommended in the table above are repeated below, with cost estimates.

Table 5.16: Recommended additional measures, cost estimates as per Monte Carlo simulation

Hazard/scenario	Residual risk	Additional risk mitigation measure proposed by the independent risk assessment team	Cost estimates (incremental costs)* in USD
Unit 1 (existing facilities)			

Hazard/scenario	Residual risk	Additional risk mitigation measure proposed by the independent risk assessment team	Cost estimates (incremental costs)* in USD
Corrosion leading to pipe and wellhead leakage and rupture	5B (H)	<ul style="list-style-type: none"> Install visible warning signs for all personnel (Well Pad 30). Remove the unused tank at Well pad 30 using forklift and transport with truck to the backfill. 	150 USD
Direct contact to process pipe surface leading to personal injury and / or asset damage	3A (H)	<ul style="list-style-type: none"> Repair damaged insulation on the loop pipeline in gathering system, especially at location near volcanology Research Center and well pad 9. 	110 USD
Brine pond overflow, leading to groundwater and soil pollution, damage of farmland	3D (E)	<ul style="list-style-type: none"> Pond Revitalization (Well pad 30 and Well Pad 10). 	1,600 USD
Silica Compounds around the pond and scaling pipe.	3B (M)	<ul style="list-style-type: none"> Provide dedicated and protected place for collected silica from all well pads (7, 28 and 30) Include silica management in SOP of hazardous material waste management 	16,000 USD
Sabotage causing fire or loss production potential to personal injury, downtime, damage to asset, reputation, and social impact	2B (L)	<ul style="list-style-type: none"> Improve access control to existing wells pads 9, 29 and 30 including fencing, gate and security guard. 	1,600 USD
Theft causing loss asset potential to personal injury, downtime, damage to asset, reputation, and social impact	2B (L)	<ul style="list-style-type: none"> As Above 	1,600 USD (included in above)
Unit 2 (construction)			
Nearby communities exposed H ₂ S from silencer causing eye irritation, bad odor and headache.	5C (E)	<ul style="list-style-type: none"> Optimization of community counseling/simulation to handling H₂S exposure by GDE Peduli (CSR) or third party. 	1,500 USD
Unit 2 (operation)			
Malfunction of control system and safety device leading to rupture at storage Tank of Organic Fluid (Butane and Pentane) rupture. Potentially explosion, injury of people.	5C (E)	<ul style="list-style-type: none"> EPC contractor to conduct detailed risk assessment as part of DED, and to consider installation of blast wall as needed 	35,000 USD

Notes: * Estimation cost carried out by Monte Carlo Simulation.

5.4.3 Risk of explosion resulting from rupture in organic fluid storage tank

381. The risk and possible consequences of explosion resulting from rupture in the organic fluid storage tank (Butane and Pentane) as been assessed through ALOHA simulation. Table 5.17 presents the assumptions used for the ALOHA simulation in Dieng Unit 2 for the ORC process flow.

382. **Worst-case scenario.** The simulation focused on a postulated worst-case scenario associated with storage of butane and propane. The worst case release is designed to represent the upper bound catastrophic, conservative situation; it assumes complete release of the quantity held in the largest vessel at the facility, and assumes (contrary to the law of Physics) that the entire mass is available for a vapor cloud explosion. This scenario does not take into consideration the mitigation measures and assumes failure of all active safety systems and absence of emergency response to reduce the impacts and risk. Direct source option for flammable source strength is used due to limited information about a release in the butane and pentane storage tank. The model of direct release is using Heavy Gas Dispersion. Butane and propane is a liquid substance in a pressurized storage tank.

383. Maximum quantity of Butane and Pentane Storage is not defined yet in the FS document. Therefore, determination of the volume input in this case was based on *US EPA List of Regulated Substances and Thresholds for Accidental Release Prevention*.

384. Weather data sampling was collected from 9-16 August 2019. Data was taken at 10:00AM and 10:00PM. No wind speed data was noted on WSW, W and NW. Each data is simulated in ALOHA and data with stability ranking F (12 August 2019, 10:00AM) was selected for further simulation. LEL for Butane is 16,000 ppm. Release rate for Butane is 167lbs/s with leakage source height from the ground is 0.

Table 5.17: Assumptions used for the ALOHA simulation

ALOHA Tab	No	Data	Input	Assumption (If Input Unavailable)	Reference
Site Data	1	Elevation	6872 ft (2035m)		Google Earth
	2	Coordination	Latitude Deg: 7, Min: 12 S, Longitude, Deg: 109, Min: 54 E Latitude Deg: 7, 211 S, Longitude, Deg: 109,884 E		Google Earth
	3	Time	-7.00, GMT Standard Time		Standard Time
	4	Building	Enclosed Office		Feasibility Study
	5	Date	9 August 2019, 00:00		The lowest stability weather data sampling from 9 August – 16 August 2019
Set Up	6	Chemical	Butane and Pentane		
Atmospheric (User Input)	7	Wind Speed	1.3 m/s		Meteoblue.com
	8	Wind Direction	ESE		Meteoblue.com
	9	Measurement Height Above Ground	10 m		

	10	Ground Roughness ⁴²	Farmland with very few buildings/trees : 0.03m (3cm)		
	11	Select Cloud Cover	2%		Meteoblue.com
	12	Air Temperature	18.6 °C		Meteoblue.com
	13	Stability Class	F		ALOHA calculation
	14	Inversion	-		
	15	Humidity	47%		Meteoblue.com
<u>Source Strength (Direct Source)</u>	16	Unit		Pounds	
	17	Scenario source		Instantaneous	
	18	The amount of pollutant		10,000lbs	
	19	Enter Source Height		0 meter	
	20	Chemical stored (gas /liquid)		Liquid	
		Stored Temperature	Ambient Temperature		
<u>Calculation Option</u>	21	Use Heavy Gas Dispersion only			
<u>Display (Threat Zone)</u>	22	Hazard to analyze	Flammable area of Vapor Cloud/Blast Area of Vapor Cloud Explosion		

385. The results of the ALOHA simulation for this worst-case scenario are presented **Error! Reference source not found.** The resulting threat zone distance is presented below:

- Red Threat Zone: 336 meters --- (9600 ppm = 60% LEL (Lower Explosive Limit = Flame Pockets)
- Yellow Threat Zone: 885 meters --- (1600 ppm = 10% LEL)

386. The result of this simulation (Figure 2) shows that the red threat zone for the worst-case scenario reaches the community nearby (Karang Tengah Village) and adjacent agriculture areas, while the yellow threat zone reaches a few areas of Telaga Merdada (Lake).

⁴² Petersen, Erik L., Niels G. Mortensen, Lars Landberg, Jorgen Hojstrup and Helmut P. Frank. (1997): Wind Power Meteorology. Weather and Climate: 10-11.

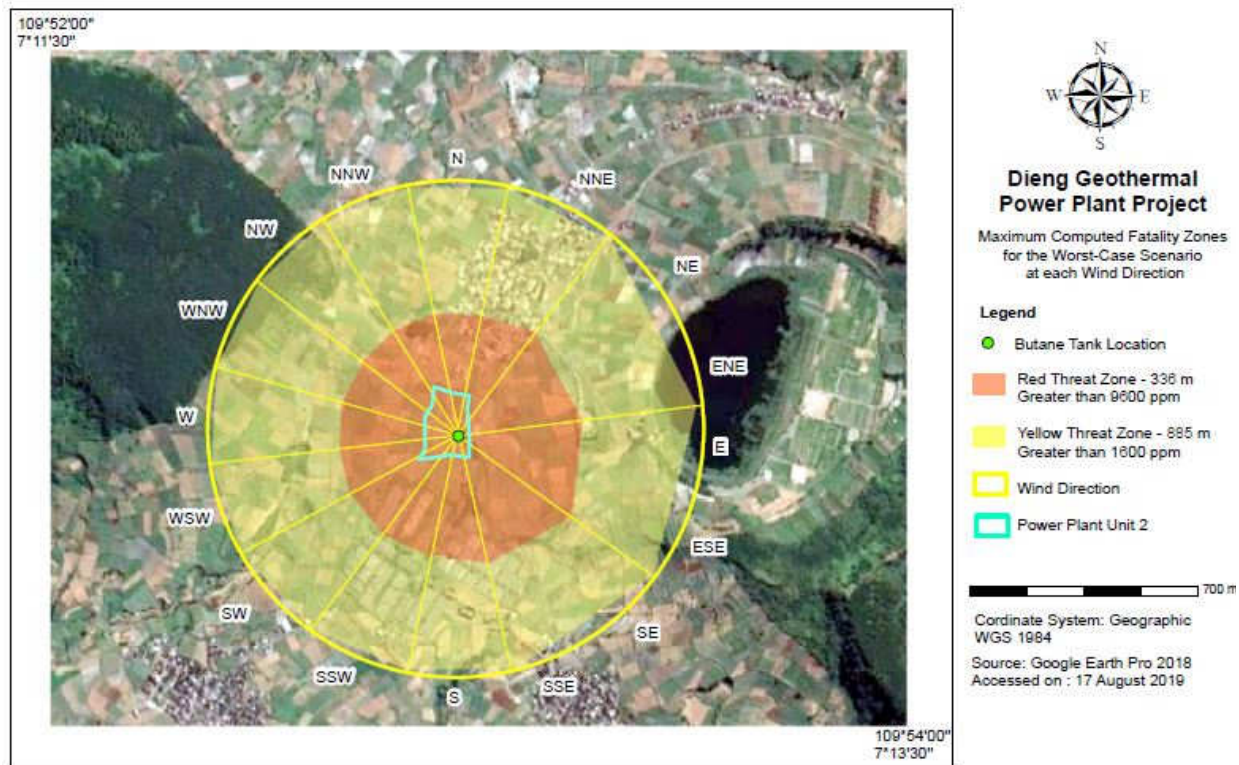


Figure 5.8: ALOHA simulation for rupture of organic fluid storage tank

387. The above simulation results should be interpreted with caution. The risk of fire/explosion due to organic fluid is limited to the butane/pentane pressurized storage tank. Since the system will be closed-loop system, there is no room for leakage. The design of the storage tank will comply with international safety codes and standards. The EPC contractor will be required to demonstrate during DED that the risk mitigation measures (covering design⁴³ as well as management measures) are able to reduce the risk to acceptable levels. The PMC will do the quality assurance of the DED and confirm to ADB and GDE the acceptability of the system, both on operability and safety. The condition of the system will be monitored 24/7 at the control room with state-of-the art instrumentation system. Any pressure drops which could be a sign of leakage can be detected automatically at the control room and automatically shut-off remotely. The emergency preparedness and response (EP&R) system to be developed for Unit 2 in accordance with ISO14001 will include procedures to follow in case of an emergency with the organic fluid tank.

6 ANALYSIS OF ALTERNATIVES

388. This section covers the alternatives considered in the project.

6.1 “No project” option

389. A “no project” option entails that the expected contribution to increase the current installed capacity of geothermal power will not be realized. At the same time, this negates the need to

⁴³ A concrete blast wall could be built near the storage tank, shielding the nearby community.

meet the GOI target of 6.3 GW from geothermal energy by 2026.⁴⁴ Geothermal reserves not tapped for economic development means that the planned economic development and potential business opportunities within Central Java may not altogether happen due to lack of additional reliable power. Table 6.1 gives a comparison of “with-project” and “no project” options.

Table 6.1: “With project” and “no project” options

Description	“With Project” Option	“No Project” Option
Economic development	With additional supply of reliable power, there will be potential for more business opportunities in Central Java	Few opportunities, if any, due to lack of reliable power supply
Additional 55 MW of clean and renewable energy capacity for Indonesia	Will contribute to the government’s target of 6.3 GW by 2026 Will contribute to the government’s target of 23% renewable energy by 2025	No additional power generation capacity
Global status of Indonesia as major producer of geothermal energy	As of end 2018, Indonesia is next to the USA as the world’s top producer of geothermal power displacing the Philippines to 3rd place. Additional capacity of 55 MW will be contributed to the installed capacity of 1,948 MW as of end 2018.	No contribution
Potential impacts to ecologically-sensitive areas	Internationally-recognized Pegunungan Important Bird Area is overlapped by the northern part of the Project but will not be adversely affected. A critical habitat assessment and bird survey were done within March and May 2019 and as a result, the design of transmission line was changed to minimize the potential impacts to migratory birds.	Local residents may continue to use remaining available land for agriculture
Potential impacts to terrestrial flora and fauna	Project site is not known to host endangered or protected species of terrestrial flora and fauna. Areas within the project site are extensively agricultural planted to potatoes, cabbage, carrots and onions by local people.	No impact
Potential impacts to aquatic flora and fauna	Cidolog River and Tulis River may be sourced to provide water during well development. These rivers are not known to host species of conservation status	Local residents will continue to use Cidolog River and Tulis River
Use of water	Extent of water use from Cidolog River and Tulis River during well development (about 18 months) will consider other users like farmers.	Local residents will continue to use Cidolog River and Tulis River

⁴⁴ Government Regulation No. 79/2014 on National Energy Policy. Adopted by Parliament on 17 October 2014 replacing the 2006 National Energy Plan. <https://www.iea.org/policiesandmeasures/pams/indonesia/name-140164-en.php>.

Description	“With Project” Option	“No Project” Option
	Condensate from the existing Unit 1 will be used as water supply during well development. Air-cooled cooling towers will be used during operation of power plant so there will be no water requirements for cooling.	
GHG emissions	Unit 2 will use combined cycle power plant technology consisting of: steam turbine, ORC bottoming turbine, and ORC brine. The GHG emission generated annually from Unit 2 will be 0.045 tCO ₂ e, a reduction of 356,883 tCO ₂ e per year (estimated from Java grid emission factor).	GHG emissions will come from other anthropogenic sources like vehicular emissions and extensive agricultural use of the land. Natural sources will come from the geothermal field (Sikidang and Sileri areas).
Disruption to local residents within the project area	Potential impacts or disruption to daily activities will be minimal (i.e., temporary and short duration during construction/installation). Any disruption can be mitigated by proper construction planning and scheduling of activities. Transport of drilling equipment, heavy equipment and machinery like turbine will be scheduled and coordinated with the local authorities, village heads and the affected communities.	None
Employment	Will create jobs both for skilled and unskilled persons. Local hiring will be given priority There will be opportunities for small-scale business opportunities like provision of temporary accommodation, food, and other relevant services.	None

6.2 “With project” options

6.2.1 Site suitability

390. Geothermal resource is site-specific and power plants must be located close to the geothermal source. This constraint reduces the choices for an efficient location of the power plant. Based on previous studies by experts, the Dieng geothermal field can accommodate about 400 MW of commercial viability.⁴⁵ With this estimated capacity, additional units of up to four power plants can be accommodated. At present, there is an existing Dieng Unit 1 (55MW) that started commercial operation in 1998. Dieng Unit 2 will be located about 3 km north west of Unit 1 on an elevated land of about 6 hectares.

⁴⁵ PWC. Final Report Consultant’s Services for the Development of Geothermal Area Dieng Units 2 & 3 and Patuha Units 2 & 3. 4 October 2013.

6.2.2 Renewable energy utilization

391. As of 2018, the energy mix in Indonesia is predominantly coal (61.94%) followed by natural gas (20.85%) and less than 10% contributions from hydropower (6.94%), geothermal (5.37) and oil (4.24%). Other types of renewable energy (i.e., solar, wind, biomass, etc.) contribute to less than 0.5%

392. The Government Regulation No. 79/2014 on National Energy Policy (2014 NEP) targets a national energy mix from new and renewable energy sources to 23% by 2025 and 31% by 2050.⁴⁶ The 23% goal from renewable energy consists of bioenergy (10%), geothermal (7%), hydropower (3%), and other new and renewable energy sources (3%). Dieng 2 will contribute 55 MW to the national target of 7% geothermal. Compared to other renewable energy such as wind and solar, the geothermal source can provide a reliable baseload power. Geothermal energy utilization is not affected by climate change compared to hydropower.⁴⁷ Since geothermal is considered renewable energy, it is not affected by changes in prices of fossil fuels and is the only renewable energy with a potential capacity factor of more than 80% with some plants recorded a capacity factor of 90%, higher than fossil-fuel fired power plants.⁴⁸ In terms of land requirements, geothermal power plants require less land compared to hydropower with storage or coal-fired power plants.⁴⁹

393. Aside from contributing to the national targets, renewable energy utilization through geothermal power development is consistent with the Energy Policy 2009 of ADB where promoting energy efficiency and renewable energy is one of the pillars of policy implementation.

6.2.3 Options for cooling system

394. Water is predominantly used for cooling in geothermal power plants which is generally through closed-loop (recirculating) cooling systems. This system withdraws and consumes water, but not all water withdrawn is consumed. Small amount of water lost through evaporation is replaced as make-up water. Unit 2 considered the following options and the main consideration for selecting air-cooled system is due to limited water supply within the project site. Table 6.2 gives a comparison of cooling systems while Figure 6.1 shows the schematic diagram.

Table 6.2: Analysis of different cooling systems

Type of Cooling System	Description	Advantage/Disadvantage
Forced draft cooling tower system (or closed-loop cooling system)	Wet-recirculating or closed loop systems reuse cooling water in a second cycle rather than immediately discharging it back to the	Substantial amount of water required during start-up to fill the basin Once in operation, low water requirement to replace any water

⁴⁶ PWC. Power In Indonesia Investment and Taxation Guide. November 2018, 6th Edition.

⁴⁷ Goldstein, B., G. Hiriart, R. Bertani, C. Bromley, L. Gutiérrez-Negrín, E. Huenges, H. Muraoka, A. Ragnarsson, J. Tester, V. Zui, 2011: Geothermal Energy. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

⁴⁸ International Renewable Energy Agency, Geothermal Power Technology Brief, September 2017. www.irena.org

⁴⁹ The International Bank for Reconstruction and Development/World Bank. Energy Sector Management Assistance Program. Geothermal Handbook: Planning and Financing Power Generation. June 2012.

Type of Cooling System	Description	Advantage/Disadvantage
	original water source. Most commonly, wet recirculating systems use cooling towers to expose water to ambient air. Some of the water evaporates; the rest is then sent back to the condenser in the power plant.	lost through evaporation in the cooling tower. Requires water treatment chemicals to prevent bio-fouling Creates low-level noise due to the cascading water in the cooling tower Produces large visible plume as the warm saturated air that leaves the cooling tower mixes with the cold ambient air and the water vapor condenses
Forced draft air cooling system (or air cooled condenser)	Dry-cooling systems use air instead of water to cool the steam exiting a turbine.	No need for water to cool the power plant system Cooling performance may be affected by ambient air temperature Expensive system compared to other cooling systems. Advisable to use only if water is not available. Typically taller due to large ground clearance needed to deliver air to the fans. Low-noise fans are available for air-cooling system No visible white plume from the cooling tower

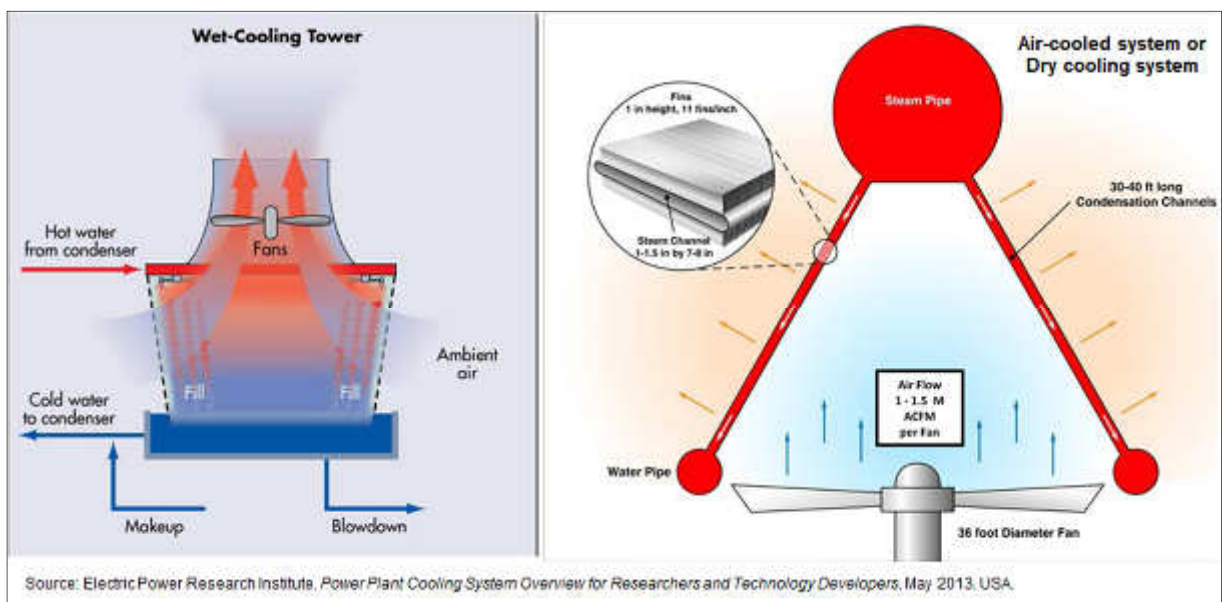


Figure 6.1: Schematic diagram of a cooling system

6.2.4 Options for the alignment of power transmission line

395. The transmission line route will connect Unit 2 to the existing substation in Unit 1. Three options for the type and alignment of the transmission line were considered. The summary of the options considered is given in Table 6.3 while the cost estimates is shown in Table 6.4.

Table 6.3: Summary of the environmental and social impacts of the transmission line

Option	Description	Total Length (km)	Impact to Ecologically-Sensitive Areas			Risks of bird collision	Land Acquisition
			IBA/KBA and critical area	Protection Forest			
				Yes/ No	Area (km²)		
1	Overhead transmission line (OHTL)	3.1	No	Yes (*)	29,000 m²	Yes	Towers = 4800 m²
							Corridor = 62,000 m²
2-1	Underground cable (UGC) to be laid along existing roads	6.9	No	No	0	No	No
2-2	UGC to be laid along existing roads with section through private lands when approaching Dieng Unit 1 substation	5.7	No	Yes	264 m²	No	Surface = 264 m² terminating at Dieng Unit 1
3	Combination OHTL and UGC	OHL = 1.7 UGC = 2.5	No	No	0	Yes	Towers = 2800 m²
							Corridor = 34,000 m²
Note: IBA – Important Bird Area; KBA – Key Biodiversity Area							

Table 6.4: Cost Estimates of the Transmission Line Options

No.	Description	Cost Estimate (\$)
Option 1	(OHTL) Length is 3 km; double circuit	1,166,037
Option 2	(UGC) Length is 6.9 km; 150kV UGC, two feeders	4,333,200
Option 3	(OHTL + UGC) OHTL is 1.7 km; UGC is 2.5 km; double circuit	2,646,182

396. Based on the options considered, Option 1 will be the cheapest but will have significant environmental and social impacts. For environment, an above-ground solution would potentially significantly impact migratory birds of prey, as shown in the biodiversity impact assessment prepared for the project (Appendix 5b). The route for Option 1 is within an area of modified habitat

mainly agricultural but adjacent to forest area (shaded green from Figure 6.2) and the IBA/KBA (shaded purple in Figure 6.2).



Figure 6.2: Location of Option 1



Figure 6.3: Location of Option 2-1

397. There are two options for the underground cable technology (UGC). The use of UGC will have less potential environmental impacts. Options 2-1 for UGC will be laid along the existing road turning to the northern side of the Sikidang Crater (Figure 6.3). The cable can be laid either below the asphalt road or within the 10 m-wide GDE corridor reserved for the steam pipelines (in orange – UGC to be laid along the existing roads with a total length of about 6.9 km).

398. While Option 2-2 will be UGC, part of the alignment will require land acquisition (in orange – UGC to be laid along the existing roads with a short cut through private lands when approaching Dieng 1 substation, total length of about 5.7 km in Figure 6.4).



Figure 6.4: Location of Option 2-2

399. Option 3 will be a combination of OHL and UGC. The route will start as an OHL of about 1.7 km then towards the south along 2.5 km as UGC (Figure 6.5).

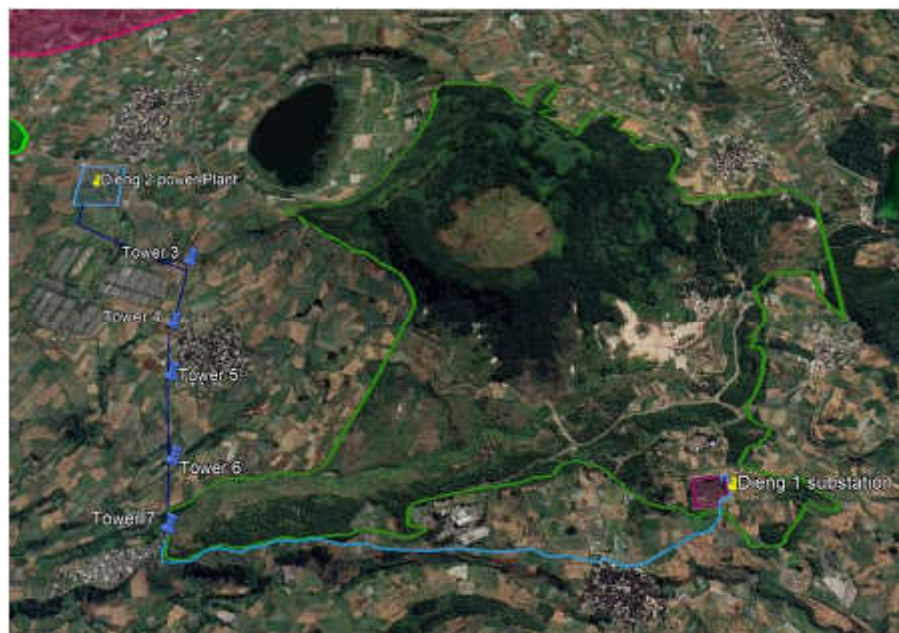


Figure 6.5: Location of Option 3

400. While Option 2-1 is the most expensive, it will have less environmental impacts and no land acquisition that may potentially affect the schedule of project implementation due to negotiations for compensation. Given the above, GDE decided to opt for Option 2-1, i.e. the most expensive but least intrusive option.

7 INFORMATION DISCLOSURE, CONSULTATION, PARTICIPATION

7.1 Introduction

401. Stakeholder engagement, which covers meaningful consultation, participation, and disclosure of information is one of the key elements of environmental due diligence undertaken for this project. Consultations aim to engage key stakeholders throughout the project cycle and to know their concerns and perceptions, if any, about the project. Public consultation events provide opportunities for the affected people to share their views on the project and also for GDE to present to the stakeholders relevant information of the project. The consultation is not limited during the preparation of this IEE but it will be carried out during project implementation.

402. Consultations were conducted as part of the requirements of the ADB's SPS 2009. Specific objectives of consultations included the following:

- (i) To ensure peoples' participation in the proposed project;
- (ii) To inform key stakeholders about the project, its environmental implications within the project area, potential environmental impacts and mitigation measures, and project benefits;
- (iii) To determine the concerns of the people about the project and discuss possible solutions;
- (iv) To describe the mechanism for handling potential complaints or grievance related to the project; and
- (v) To inform stakeholders on access to information about the project.

7.1.1 National requirements for public participations

403. Public consultations are integral part of national development projects. Key laws and regulations that require a form of public participation and disclosure of information, among others, are listed in Table 7.1.

Table 7.1: Key Laws and Regulations Mandating Public Participation

Regulation	Description
Law No. 32 of 2009 on Environmental Protection and Management	Chapter XI, Article 70 provides for communities to have equal and broad right and opportunity to participate actively in environmental protection and management.
Law No. 14 of 2008 on Disclosure of Public Information	Provides that the right to information is a human right and public information disclosure is one important characteristic of a democratic state
Law No. 21 of 2014 on Geothermal	Exploration of geothermal resources has an important role to support sustainable development for the people's welfare, and thus, will require public participation

Regulation	Description
Law No. 2 of 2012 on Acquisition of Land for Development in the Public Interest	This provides for direct or indirect participation in the performance of land acquisition from planning to construction activity.
Presidential Regulation No. 62 of 2018 on Handling Social and Community Impacts in the Provision of Land for National Development.	Provides for the Handling Social Community Impacts in the Framework of Provision of Land for National Development.

7.1.2 Consultation based on SPS 2009

404. Key elements required by ADB SPS (2009) for meaningful public consultations include the following:

- (i) it should be carried out at the early stage of project preparation and throughout the project cycle;
- (ii) timely disclosure of relevant and adequate information that will be understood and can be easily accessed by affected people;
- (iii) carried out free of intimidation or coercion;
- (iv) process is gender-inclusive, responsive, and fit to the needs of disadvantaged and vulnerable groups; and,
- (v) be able to incorporate relevant views from the stakeholders' engagement into decision-making.

405. The process and outcome of the stakeholders' engagement are documented and included in this IEE.

7.2 Consultation Methodology

406. **Identification of stakeholders.** The stakeholders are considered to be primary if they will be potentially affected during pre-construction, construction, operation and decommissioning of Dieng Unit 2. These are the villages of Kepakisan, Sikunang, Bakal, Dieng Kulon, Karang Tengah, and Pranten. Secondary stakeholders are persons, organizations, or businesses that may not be directly affected but may have interests on the project such as relevant government agencies, NGOs, farmers' cooperative, and the general public.

407. **Approach.** Two public consultation events for the development of Dieng Unit 2 were carried out at the village halls of the aforementioned villages on 20 – 22 March 2019 and on 11 – 13 September 2019. The participants of these public consultation events were invited by GDE through their respective village heads.

- (i) **The Consultation in March 2019.** The consultations were co-chaired by GDE staff and ADB team including their consultants. The program started with opening remarks from the village head and subdistrict head followed by a brief explanation from GDE staff about the planned development of Dieng Unit 2. ADB staff gave a short explanation about the safeguard principles embodied in ADB's SPS (2009), gender, and the purpose of the consultations. The consultations were conducted in *Bahasa Indonesia* and followed by question and answer sessions as well as small group discussions on community concerns and perceived environmental risks associated with

Dieng Unit 2 development. The participants raised their concerns quite actively, and these were responded to by GDE and/or ADB consultants.



Figure 7.1: Public Consultation in Dieng, March 2019

- (ii) **The Consultation in September 2019.** The participants were gathered in the village halls likewise the consultation in March 2019. Consultations began with the national anthem followed by a prayer and then the village head and/or representative gave a short welcome address. GDE made the presentation on the planned development of Dieng Unit 2. The ADB consultants presented significant findings from social, environmental, and gender assessments using powerpoint slides. The participants were then given the chance for questions and/or raise their concerns and perceived environmental risks about the mentioned development. Questions raised were responded to by GDE and the ADB consultants. Presentations and discussions were all done in Indonesia language.



Figure 7.2: Public Consultation in Dieng, September 2019

408. **Record of consultations.** General information of the participants such as name, gender, occupation, and signature were collected and shown in the attendance list. Full reports of the March and September 2019 consultations are included in Appendix 1.

7.3 Results of Public Consultations during the preparation of the IEE

7.3.1 The Consultations in March 2019

409. It was conducted at the village halls and attended by a total of 183 persons, including 139 males (76%) and 44 females (24%). The participants of the consultations included community members (that include potential affected persons) living close to the project areas in affected villages, representatives of village government officials, community-based organizations (including PKK, Karang Taruna, Bumdes, elderly groups), sub-district government, districts agencies, among others Environment and Spatial Planning, GDE Headquarters and Dieng unit, the TA consultants, and ADB. Table 7.2 presents the breakdown of participants at the consultations. Table 7.3 provides the summary of environmental concerns and perceived risks raised in the March 2019 consultation and corresponding responses.

Table 7.2: Profile of Participants during Consultations, March 2019

Village	Sub-district/District (Kecamatan/Kabupaten)	No of Male Participants (Percentage of Total Participant)	No of Female Participants (Percentage of Total Participant)
Dieng Kulon	Batur (Banjarnegara District)	25 (74%)	9 (26%)
Kepakisan	Batur (Banjarnegara District)	10 (50%)	10 (50%)
Bakal	Batur (Banjarnegara District)	38 (93%)	3 (7%)
Karang Tengah	Banjar (Banjarnegara District)	28 (74%)	10 (26%)
Sikunang	Kejajar (Wonosobo District)	16 (73%)	6 (27%)
Pranten	Bawang (Batang District)	22 (79%)	6 (21%)
Total		139 (76%)	44 (24%)

Table 7.3: Summary of Public Consultations in March 2019

Key Issues Raised	Responses
<p>The decline of water quality since Dieng 1 has been operating. Some spring water, especially near GDE wells, are no longer drinkable due to its sulfur odor and saline taste. Some participants were concerned on their health when drinking the current water sources.</p> <p>The residents in Sikunang Village took their own water sample to Gadjah Mada University (UGM) for analysis. They claimed the results showed a positive test for sulfur content.</p>	<p>The residents and the district Environmental Agency propose to conduct water tests in an accredited laboratory and be informed about the results openly to the residents.</p> <p>GDE's HSE staff conducted several water quality tests, indicating that Dieng 1 operation has no impact on water quality.</p>
<p>Two consulted villages complained about pollution from wastewater from the Dieng 1 operation to the spring water and the farmland resulting in the death of the vegetation.</p>	
<p>All consulted villages complained about the steam blowing from the Dieng Unit 1 well reportedly causing accelerated corrosion of their house roof (made of galvanized zinc sheet).</p>	<p>GDE has paid compensation for lost crop and provided corrugated zinc sheets to replace corroded roofs.</p>

Key Issues Raised	Responses
<p>The leakage of steam caused damages to crop and zinc roofs over the last two years on settlements of Praten Hamlet close to Wellpad #30.</p> <p>Residents claimed loss of planting period and income for 1 year and other damages have made residents have to sell their assets and engaged in debt.</p> <p>The steam leaks also caused the death of wood plants in the forests around the wellpad #30, which then caused landslides in some parts of the protection forest hills.</p> <p>The residents also claimed that the case of steam leak has triggered the emergence of new steam craters around the settlements, which will endanger the lives of the residents.</p>	<p>This concern is noted, but there is no information known yet on the relationship of Dieng Unit 1 operation and the corroded roof as well as creation of new craters claimed by the community.</p>
<p>The turbine explosion that occurred at Dieng Unit 1 power plant in 2015 has resulted in flying metal objects hitting the roofs of residents' houses in Sikunang Village due to being crushed by fragments of iron material.</p> <p>The residents were worried that similar cases may occur and asked the GDE to guarantee the safety of the residents living near the project.</p>	<p>Risk assessment and measurement of noise baseline level will be undertaken as part of the IEE preparation to enable impact assessment with this regard, and define the required mitigation and monitoring plan. Safety of communities is a key priority for GDE.</p>
<p>The installation of SAGS pipeline at Sikunang resulted to restrictions in the access to farmlands, causing a decline of the land prices. The community was informed that the pipeline installation was temporary, but until now it has remained there.</p>	<p>The concern is noted. SAGS of Unit 1 will not be used for Unit 2. GDE will look into allegations and see how SAGS for Unit 1 can be improved to facilitate access to the farmlands. .</p>
<p>Some residents and the Social Agency are worried about the visual impact of the steam pipeline networks on the scenic landscape of Dieng Plateau.</p>	<p>The existing pipeline is required for the operation of Unit 1. The design of the pipelines followed the safety codes and standards of Indonesia and the international industry requirements . For Unit 2, the design of the steam pipeline will consider the inherent landscape of Dieng, a design approach known as “design with nature”.</p>
<p>When cleaning the waste pipe is done, often the waste spills are left uncleaned on the roadside. This waste contains silica, and may endanger the health of the residents and the environment.</p>	<p>A safety risk assessment was conducted by a 3rd party provider to look into the operations of GDE. The recommendations from this assessment will be implemented to ensure safety of GDE staff and the community.</p> <p>Also, the community safety during the mobilization/demobilization of heavy vehicles and equipment during construction will be a priority for GDE and will be included in the environmental assessment.</p>
<p>Residents of Karang Tengah claims that the installation of the steam pipelines closed the</p>	<p>This matter will be investigated.</p>

Key Issues Raised	Responses
<p>drainage channel causing flooding to the lower village.</p> <p>Some villages complained that there is no temporary garbage disposal in the village and hoped that GDE would help to build a temporary dumping place and a car carrying garbage to a landfill.</p>	<p>The request for garbage collection, disposal and vehicles will require consultations with the local government.</p>
<p>Representatives from Sikunang and Pranten villages complained about the noise level generated by GDE power plant, particularly at night.</p>	<p>This concern is noted. GDE uses a 10-m high mufflers/silencers as a form of enclosure to contain the noise level. This is the best available measure employed in geothermal power plants in Indonesia. Also, ambient noise levels are monitored quarterly by a 3rd party environmental monitoring company as required by MOEF. Unit 2 will comply with the ambient noise levels set by Indonesia and international noise standards such as the International Finance Corporation and the World Bank..</p>
<p>Vibration due to heavy vehicle passing needs attention. Also, the impact on road conditions and security, especially children because the road passed by the heavy vehicles is very narrow.</p>	<p>The community safety will be considered in all the stages of the project. During mobilization/demobilization of heavy vehicles and equipment, measures like traffic management, temporary crossings to accommodate elderly, children and persons with disabilities will be provided. GDE will ensure that these measures and all other community safety precautions will be implemented. as part of the mitigation plan for Unit 2..</p>
<p>Some residents stated that there is a possibility Javanese eagles in protected forests near Dieng 1 and an impact study on this species is needed.</p>	<p>A bird survey was conducted in March 2019 including a critical habitat assessment done by international expert on biodiversity. Design measures were included in Unit 2 to ensure there will be no negative impacts to the environment.</p>
<p>Some residents in Sikuang are concerned about the existence of transmission line to the community safety and fertility of the land under the ROW.</p>	<p>The concern is noted. Transmission line will be underground to ensure that there will be no impacts to the migratory birds including Javanese eagle. With the underground cable, farmers can continue to plant some herbal vegetation and agricultural crops along the right of way but trees and shrubs with large roots will not be allowed. This is required to protect the cables and for safety reasons. There will be clear and visible marks along the route to guide the farmers.</p>

7.3.2 The Consultations in September 2019

410. Similar to the consultation in March 2019, these events were conducted at the village halls and attended by a total of 178 persons, including 126 males (71%) and 52 females (29%). The total number of participants attending the consultations in September was less than those in March 2019. However, the number of women attending the consultation in September 2019 was

52 persons and this is higher compared to 44 persons attending the event in March 2019. The types of participants who attended the September 2019 consultation were similar to those in March 2019. Table 7.4 presents the breakdown of participants at the consultations. Table 7.5 provides the summary of environmental concerns and perceived risks raised in the September 2019 consultation. Summary of responses provided in the consultation is also provided in the following table.

Table 7.4: Profile of Participants during Consultations, September 2019

Village	Sub-district/District (Kecamatan/Kabupaten)	No of Male Participants (Percentage of Total Participant)	No of Female Participants (Percentage of Total Participant)
Dieng Kulon	Batur (Banjarnegara District)	19 (86%)	3 (14%)
Kepakisan	Batur (Banjarnegara District)	16 (62%)	10 (38%)
Bakal	Batur (Banjarnegara District)	24 (86%)	4 (14%)
Karang Tengah	Banjar (Banjarnegara District)	21 (84%)	4 (16%)
Sikunang	Kejajar (Wonosobo District)	36 (61%)	23 (39%)
Pranten	Bawang (Batang District)	10 (56%)	8 (44%)
Total		126 (71%)	52 (29%)

Table 7.5: Summary of Public Consultations in September 2019

Key Issues Raised	Responses
Inconsistent delivery of project information related to Dieng Unit 2.	Disclosure of project information will be coordinated and communicated through designated division/personnel at GDE.
They expected an MOU between GDE and the village government as a form of commitment that will uphold the community's right to seek compensation if the project causes environmental deterioration and disturbance to the community such as elevated noise level, frequent H ₂ S smell and exposure from the gas emitted from the rock muffler, and saline water in the community's wells	GDE will discuss this matter with related government agency, and the Company's supervisory board. Damages the environment or disturbance to the community will be remediated and compensated in accordance with relevant regulations.
The community representatives are still curious whether the operation of Dieng Unit 1 has caused accelerated corrosion of the galvanized zinc roof used by many houses in the area and is concerned that Unit 2 will have similar effect.	The relationship between the power plant operation and corroded roof is not yet known and not fully studied yet by experts. Normal operation is not contributing to corrosion.
Request for trash bins for the houses and supports for training and equipment for solid waste composting in the light of district government service on solid waste management.	GDE will consider the request.
Overflow from brine water ponds that could result to soil erosion and the uncontrolled drainage to the crop farming areas nearby.	This matter will be included in the mitigation plan of the Project and consultations with the community in due course. Some of the undersized brine ponds will be expanded.
GDE and/or its contractors to be mindful about muddy and dusty road caused by the vehicles	The need for community safety aspects during the mobilization/demobilization of heavy equipment

Key Issues Raised	Responses
entering and exiting the well pads and community safety within the proximity of school and market to avoid road accidents.	during construction will be prioritized and appropriate measures will be included in the mitigation plan of the Project.
The participants wonder if exposure to H ₂ S gas and emission from the rock muffler may cause health effects.	The H ₂ S levels will be much lower than the threshold set by Ministry of Environment Decree No. KEP-50/MENLH/11/1996 on Odour Level Standard. The white smoke coming from the rock mufflers are mainly steam and water mists.
Perceived risks that GDE operation has caused the reduction of water flow of the river and community wells particularly during the dry season.	A water study was conducted that demonstrates no conflicting water uses between GDE, crop farmers and other water users in the Dieng area. Main water consumption will be limited to well drilling – i.e short term. Condensate from Unit 1 will be used as primary water source for drilling. An additional water study is currently being conducted to confirm initial findings of the first water study. The results will be disclosed to the public.
Rehabilitation or replacement of public facilities such as road, clean water pipeline damaged by the project, and properties.	Inventory of public facilities and properties will be surveyed and documented by the contractors to avoid dispute on future claims for compensation. Any damage to structures caused by the project during construction will be repaired and compensated.
Setulu, Sedendam, and Siranti springs are reported by the community representatives as the main clean water sources for the household and farming activities. There is a perceived risk that the construction and operation of Dieng Unit 2 at Karang Tengah village will affect the availability and quality of these springs as they perceive these water sources flow underneath the Karang Tengah village.	The water quality of these springs will be studied/monitored to ensure that construction and operation of Dieng Unit 2 will not affect these springs. Representative of the community and related government agency may be engaged in this study. The springs will not be used as water source for the project.
One of the land renter coordinators at the GDE's owned land (ex-mess PLN) indicated his objections that the Dieng Unit 2 will be constructed at this particular site. His concern relates to what should be the safe distance between the future Dieng Unit 2 and the nearest residential areas at Karang Tengah.	An initial risk assessment conducted for Unit 2 confirms that the risk of future operations in case of malfunctioning and catastrophic events (explosion) on Karang Tengah will not be significant if necessary, protection measures are taken. The powerplant contractor, in charge of detailed engineering design, will be required to re-conduct and refine the risk assessment and demonstrate to the community that the risk is acceptable. The safe distance of concern will be incorporated during the detailed engineering design of the power plant and associated facilities.

7.3.3 Targeted stakeholder consultations

411. In addition to the public consultations involving potentially affected people within the area of influence (AOI), targeted stakeholder consultations were conducted in 2019 on specific issue

like biodiversity. Summary of the consultations with specialists and targeted stakeholders is presented in Table 7.6.

Table 7.6: Summary of Targeted Stakeholder Consultations

Specialist / Targeted Stakeholder	Aspects
World Wildlife Fund for Nature (WWF) Indonesia (Met on 20 August 2019)	<ul style="list-style-type: none"> • GDE met with WWF to discuss about advocacy, national policy on geothermal, and in sharing information on geothermal development in Indonesia. • In 2013, WWF actively promoted the “Ring of Fire” program through the use of geothermal as renewable energy in the Southeast Asia. Their vision is a “world powered by 100% renewable energy by 2050”. Along with this, is their vision for developing Indonesia’s geothermal power sustainably in partnership with the affected communities such as in Sumatera and Flores. • WWF has produced Sustainability Guidelines for Geothermal Development and developed a module on stakeholder engagement focusing on the importance of awareness-raising of communities on geothermal power development based on their experience in Sumatera.
<i>Wahana Lingkungan Hidup Indonesia</i> (WALHI), Indonesian Forum for the Environment founded in 1980 (Met on 22 August 2019)	<ul style="list-style-type: none"> • They have several campaigns on protected forest and biodiversity in central and west Java. • They would be concerned if communities will be marginalized due to geothermal project but does not see this to be relevant to Dieng and Patuha. • Expressed their concern to Patuha as Pertuhani opened protected forest for economic activities and recommended for GDE to coordinate with Aspinall Foundation as they have the expertise on the Patuha protected forest. • Dieng 2 is considered not an issue as the conservation area has already been cleared to potato agricultural fields. • Reminded GDE to be sensitive to local culture including community belief that dense forest areas are considered “sacred”. • Expects GDE and ADB to ensure that adverse environmental impacts due to the project are avoided and minimized.

7.4 Consultations and information during implementation

412. Consultations will continue during the implementation of Dieng Unit 2. A communication strategy plan was prepared with technical support from a consultant.⁵⁰ The communications strategy plan will provide guidance to GDE in engaging stakeholders effectively.

413. Information, education, communication (IEC) initiatives will be mapped by GDE during implementation as an important tool in forging good relationships with the communities as partners in geothermal power development in Dieng. These initiatives will serve as venue for interactions where concerns can be raised, discussed, clarified, and solutions identified.

⁵⁰ The strategy is included in the Project Administration Manual (PAM, available on www.adb.org)

414. Part of the initiative is to post a project summary in Bahasa on the GDE' website, a one-page flyer in Indonesia language Bahasa about project brief including details on GRM to be made available at GDE's Dieng office, GDE headquarters, and village offices. A simple Q & A flyer/brochure (using Indonesia language) on the potential impacts, mitigation measures, and benefits from geothermal energy utilization will be prepared and made available to schools, government offices, and interested individuals within the project AOI.

415. The HSE staff together with Public Affairs staff of GDE will explore opportunities to get involved in local initiatives related to environmental management. GDE will invite a village representative to join as observer during the environmental monitoring to be conducted by a 3rd party consulting firm. IEC initiatives and/or community engagements will be included in the environmental monitoring reports to be submitted to ADB. GDE will continue to be innovative in community engagements.

8 GRIEVANCE REDRESS MECHANISM

416. This section describes the set of arrangements that will be implemented to guide and enable local communities and other affected project stakeholders in raising their complaints to GDE if they believe that they have been adversely impacted by project activities. The grievance redress mechanism (GRM) aims to address complaints promptly in a clear and transparent process, gender responsive, culturally-appropriate, readily-accessible at no cost, and without retaliation to the complainant. The project GRM does not impede access to the judicial or administrative remedies available in Indonesia such as the complaint procedures provided for by the Ministry of Environment Regulation No. 9 of 2010 (*Permen LH 9/2010*) on Procedures of Complaint and Complaints Handling due to Allegations of Environmental Pollution and/or Damage.

8.1 Current GDE Process of Handling Complaints

417. GDE has an existing three-tiered process of handling complaints from affected persons within the areas they operate. To implement the process of grievance handling, GDE has an annual budget under the Health, Safety and Environment Unit. The existing process of grievance redress mechanism at GDE is described in Table 8.1.

Table 8.1: Current Grievance Redress Procedure in Place at GDE Patuha

Stage	Description	Procedure
1 st Level	Complainant	Informs local village head (<i>kepala desa</i>) about the concern
2 nd Level	Village Head	Sends formal letter to GDE about the issue raised on behalf of the complainant.
3 rd Level	GDE	<ul style="list-style-type: none"> (i) Only complaints filed through a formal letter from the village head are considered (ii) Community relations and HSE staff at site office check the site or impacted area to assess and verify the complaint, and to identify solution to the complaint at their level (iii) In case the complaint requires further investigation on compensation such as crop damages, verification can be done together with relevant government agency (e.g., agriculture, representative of GDE insurance company, etc.) (iv) After verification and assessment, identifies solution to the complaint (v) Works with relevant government agency to estimate damages (i.e., may be supported by independent agricultural assessor) (vi) Informs/communicates with the village head the cost estimates (vii) Together with the village head, negotiates the final solution/compensation with the complainant (viii) Compensates the complainant by bank transfers through GDE insurance companies

8.2 Handling Environmental Complaints at MOEF

418. Another way for affected persons to seek grievance on environmental issues is through the MOEF or the equivalent environmental agency based on the area of jurisdiction. *Permen LH 9/2010* regulation requires the establishment of an Environmental Complaint Post (*Pos Pengaduan LH* or ECP) to receive and respond to complaints concerning pollution and/or environmental deterioration. A summary of handling complaints according to *Permen LH 9/2010* is described in Table 8.2.

Table 8.2: Grievance Redress Procedure complaints according to *Permen LH 9/2010*

Submission of complaints	Verbal	Directly to recipient of complaints	Complainant to fill out the complainant form (Appendix 1 of the Ministerial Regulation)
		By phone	Environment Officer receiving the complaint must fill out the complainant form (Appendix 1 of the Ministerial Regulation)
	Written	Letter	Contains information on the following: (i) identity of the complainant (name, address, and contact telephone number) (ii) location of environmental pollution and/or damage (iii) alleged sources of pollution and/or environmental damage (iv) time of environmental pollution and/or damage (v) environmental media affected
		Electronic mail	
		Facsimile	
		Short message service	
		Other ways in accordance with the development of science and technology	
Action to complaints filed	If a complaint is not acted by the responsible agency within 10 days, the Complainant can go to the next higher level of government environmental agency.		
Authority of complaints	Only businesses and/or activities where environmental permits are issued by the Minister, governor or regent/mayor		
Handling of complaints	Responsible environmental agency will resolve complaint within 21 working days from receipt to recommendations		
Disclosure in handling the complaints	Responsible environmental agency will: (i) inform the complainant on the progress of handling the complaint, and (ii) provide public information in the form of data and information-handling complaints		
Cost of handling complaints	Complaint-dealing activities will be charged to Revenue and Expenditure Budget State and/or Regional Revenue and Expenditure Budget		

419. Complaints can be directly filed to the responsible environmental agency or to the village head/*lurah* (chief executive officer of subdistrict/*kelurahan*) or local *camat* (chief executive officer of district/*kecamatan*).

8.3 Project GRM

420. To streamline procedures in handling grievance and be consistent with international best practice, the PMU will establish a GRM and set-up a grievance redress committee (GRC) as soon as the loan from ADB becomes effective. Figure 8.1 shows the basic process of the GRM while Figure 8.2 shows the project GRM.

421. Objectives The GRM aims to resolve complaints due to the project in a time-bound and transparent manner. GDE will ensure that (i) efficient GRM is in place and functional to assist the affected persons and other stakeholders in resolving queries, conflicts and complaints in a timely manner; (ii) all complaints are registered, investigated and resolved in a manner consistent with the requirements of SPS 2009 and the GOI; (iii) the complainants are kept informed on the status of their concerns and the resolutions available to them; and (iv) adequate staff and resources will be made available to implement the GRM.

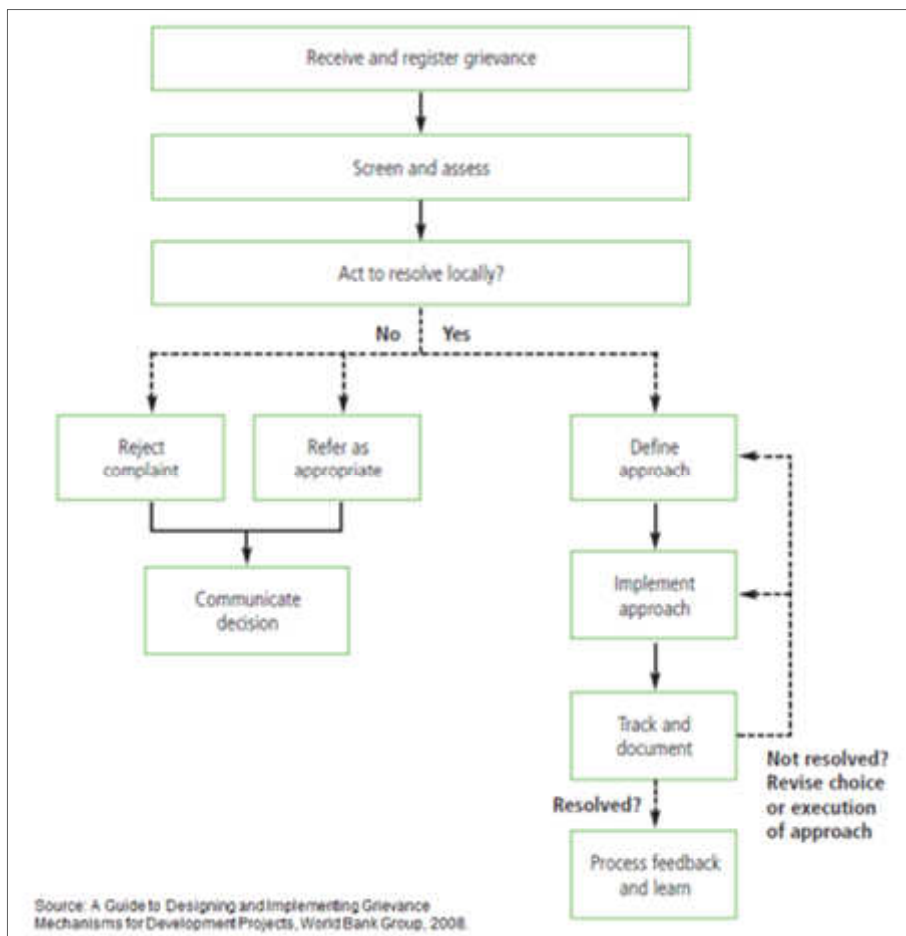


Figure 8.1: Basic grievance redress mechanism

422. Filing/submission of complaint Complaints can be lodged either verbally or written. Verbal complaints can be by phone call, walk-in or in person while written complaints could be through mail/letter, comments/suggestions drop-box, GDE website, email, or fax. A sample complaint form is given in Table 8.3. A staff will be designated by GDE as the GRM Focal Person and a suggestion/comments drop-box will be installed at the project site office. The GRM Focal Person will check the suggestion/comments drop-box weekly (every Monday). The Public Relations Staff in Dieng Unit 2 will be the GRM Focal person.

423. Record keeping The GRM Focal Person will receive, record, and sort complaints, forwards the complaints to the proper person, and monitors the status of the complaints. A logbook complaint registration and monitoring database will be created to ensure that complaints are resolved and acted on in a timely manner. A complaint record will include: (i) contact details

of the complainant, (ii) date the complaint was received, (iii) nature and type of complaint, (iv) decisions or actions taken, and (v) date the complainant was informed of the decision.

Table 8.3: Sample Grievance Redress Form

Contoh Formulir Keluhan untuk Mekanisme Penanganan Keluhan					
Formulir Keluhan/Saran/Komentar					
Nomor Pinjaman :			Nama proyek:		
Lokasi:					
Harap berikan informasi berikut:					
Tanggal Penerimaan:					
Nama Orang/Organisasi:					
Detail Kontak:					
Alamat					
Telepon / Ponsel					
Email (jika tersedia)					
Pendudukan					
Jenis kelamin					
Tanda Tangan Pengaduan Pengajuan Orang					
Apakah Anda memiliki perwakilan dalam mengajukan keluhan ini?			Iya nih		Tidak
Jika ya, silakan berikan rincian	Nama				
	Alamat				
	Telepon				
	Hubungan				
	Pendudukan				
Keluhan/Saran/Komentar (<i>Harap berikan perincian yang sesuai: apa yang terjadi, bagaimana dan mengapa itu terjadi, kapan dan di mana, berapa kali itu terjadi</i>)					
Tolong jelaskan ketidaknyamanan/kerusakan yang disebabkan atau mungkin disebabkan					
Harap berikan saran untuk penyelesaian keluhan Anda (jika ada)					
Harap beri tahu kami bagaimana Anda ingin dihubungi			Email atau email		
			Telepon		
			Pertemuan/Orang Langsung		
Hanya GDE Kontraktor/ PMU					
Direkam oleh (Nama dan penunjukan staf GDE/PMU/Kontraktor)					
Ditinjau oleh (Nama dan penunjukan staf GDE/PMU/Kontraktor)					
Tindakan yang diambil untuk menyelesaikan keluhan/komentar/saran			Tidak diperlukan tindakan		
Tindakan / keputusan diungkapkan kepada Pemohon			Iya nih		Tidak
			Tanggal		
Cara pengungkapan			Surat		

	Telepon
	Pertemuan
	Tidak dibutuhkan

Formulir Perlindungan Lingkungan PMU 1 - GRM

424. Complaints filed and resolved will be summarized and included in the semi-annual monitoring reports to be submitted by GDE to ADB during construction phase and annually during operation phase. The environmental monitoring reports are publicly disclosed at the ADB website. Transparency will be maintained on the grievances received and their resolution.

425. **Information disclosure** Procedures to file a complaint and the details of the GRM Focal Person will be disclosed by the PMU to the affected communities prior to the start of construction works. More detailed information on the GRM will be posted on billboards at the construction sites, a flyer in Bahasa to be made available at the construction project site office and the Jakarta Office, and in the GDE website. Aside from the details of the GRM Focal Person, a hotline phone number that will work 24/7 and a simplified flowchart on how to file a complaint will be disclosed to the affected communities.

426. **Cost of GRM implementation.** The PMU will review GRM implementation semi-annually to assess the effectiveness of the process and to examine GDE's ability to address grievances and conflict resolution. Cost of implementing the GRM will be part of the administration cost borne by the PMU.

427. **Levels of grievance redress.** Complainants or affected persons can seek redress to their complaints in three levels (see Figure 8.2): (i) at the project level through PMC or representative of the Contractor; (ii) at the PMU level through the grievance redress committee (GRC); and, (iii) the MOEF or the appropriate courts of law. The three-tier entry points include:

- (i) **Level 1 – Project level** Complaint to be resolved at the Project level within five working days and advise the Complainant accordingly. If the Complainant is not satisfied with the resolution, complaint will be elevated to Level 2.
- (ii) **Level 2 – PMU level through the GRC** The GRM Focal Person will assist the complainant in elevating the complaint to the GRC which is chaired by the PMU Head. The GRC will review the submission and make a decision within 30 calendar days from the date of receipt. The complainant will be informed of the decision in person, by mail or by phone. If not satisfied with the decision, the complainant can seek redress through MOEF or the appropriate courts of law (Level 3).
- (iii) **Level 3 - Appropriate Courts of Law or the MOEF** The complainant can invoke the provisions of *Permen LH 9/2010* or the appropriate courts of law. The complainant is not restricted to seek redress through the legal system at any point in the GRM process.

428. **Structure of GRC** GRC members will be the Head Office General Project Manager and the HSE and Safeguards Manager of the PMU, the head or representative from the village (*kecamatan*), the Site Office Project Manager, PR staff and HSE Staff (i.e., environment and social safeguard staff at Dieng or Patuha), the PMC, and a representative of the Contractor(s). The PMC will act as the secretariat of the GRC. GDE will ensure fair representation of women in the GRC and to observe transparency in handling complaints at all times. The GRC will be responsible to resolve complaints (if any) within a month (30 calendar days) from the date it was

received, to maintain a record of complaints received and resolved, and to advise the complainant on the decision made. The PMU (through the PMC) will create a database of complaints filed and resolved.

429. The Dieng Project Manager together with the HSE staff (Dieng) will coordinate with the EHS and Safeguards Manager (Jakarta Office) on the status of GRM implementation. Should there be complaints at the GRC level, the General Project Manager (Jakarta Office) will be informed.

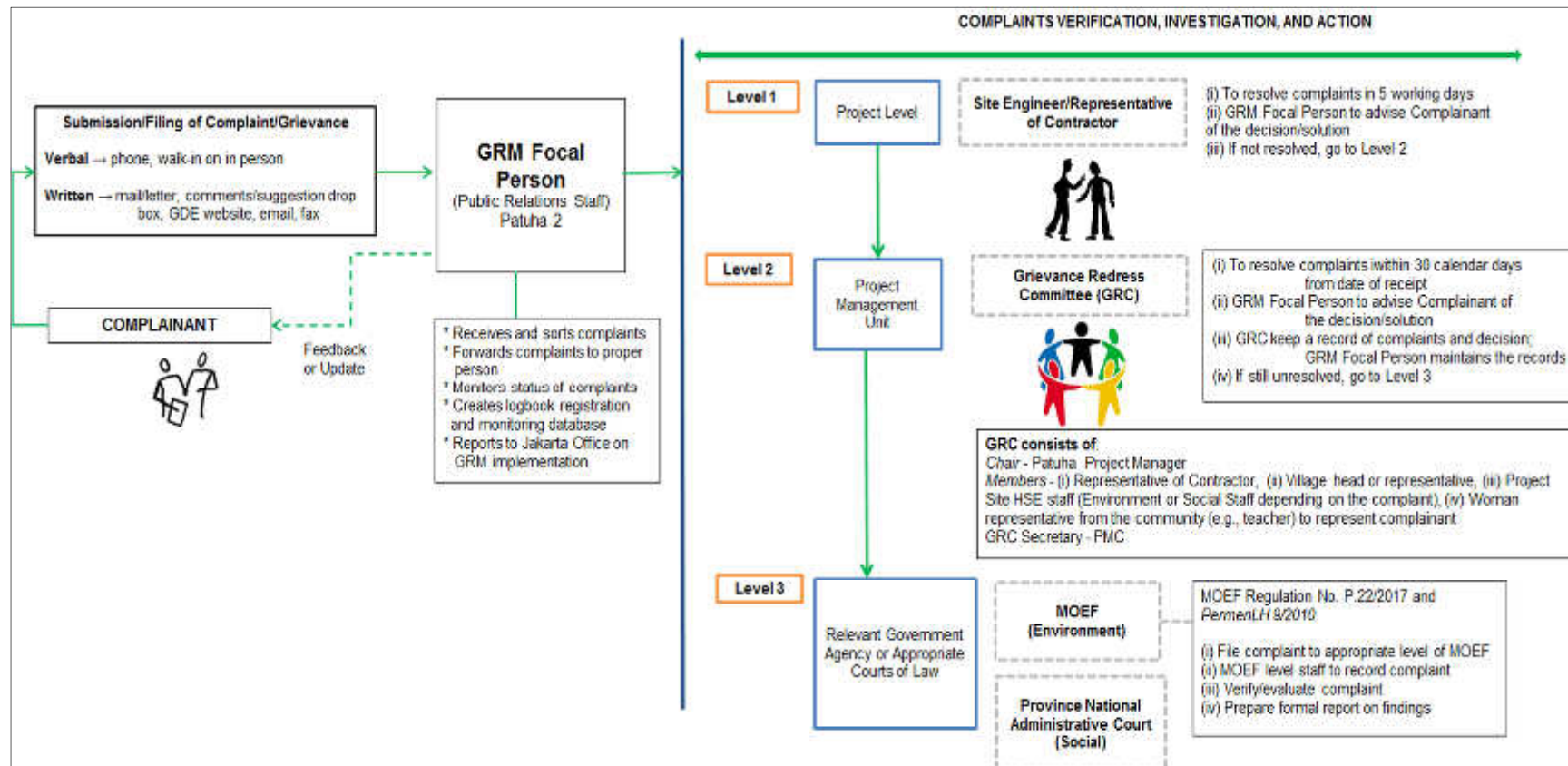


Figure 8.2: Project GRM

9 ENVIRONMENTAL MANAGEMENT PLAN

9.1 Introduction

430. This Environmental Management Plan (EMP) is developed for the Geothermal Power Generation Project (the project), Dieng component. It identifies the potential project environmental impacts and defines mitigation measures and monitoring requirements for the pre-construction, construction, and operational stages of the project. It also defines the institutional arrangements and mechanisms, the roles and responsibilities of different institutions, procedures and budgets for implementation of the EMP. The EMP seeks to ensure environmental protection activities during pre-construction, construction, and operation, continuously improve to prevent, reduce, or mitigate the adverse environmental impacts and risks.

431. This EMP is based on the Feasibility Study August 2019. Detailed engineering design (DED) is yet to be initiated, and will be done by the Project Management Consultant for the civil and enabling works (access roads, water supply, etc.) and for drilling works; and by the Engineering, Procurement and Construction (EPC) Contractor for the design, supply, construction, commissioning and testing of the power plant and SAGS facilities.

432. The EMP will be included as a separate annex in all bidding and contract documents. The contractors will be informed of their obligations to implement the EMP, and to include EMP implementation costs in their bids for project works. The PMC and EPC contractor will be required to update the EMP to reflect DED for the civil works and powerplant/SAGS, respectively, and to submit it for clearance by GDE and public disclosure on the ADB (www.adb.org).

433. The EMP includes an environmental monitoring program (EMoP). The monitoring results will be used to evaluate (i) the extent and severity of actual environmental impacts against the predicted impacts, (ii) the performance of the environmental protection measures and compliance with relevant Indonesian laws and regulations as well as internationally accepted standards as defined in the IFC-WB EHS Guidelines 2007, (iii) trends of impacts, and (iv) overall effectiveness of the project EMP.

434. The EMP is a “living document” that shall be updated by the contractor based on the then available detailed engineering before the beginning of the construction phase. In addition, the EMP shall be updated once every year, if necessary, in order to include new issues that were not or not sufficiently considered in the EMP so far. Monitoring will commence as soon as loan effectiveness date, as must include monitoring of pre-construction measures. Semi-annual monitoring reports will be submitted to ADB, even if to confirm that no works commenced.

9.2 Institutional arrangements and responsibilities for EMP implementation

435. Geo Dipa Energi (GDE) is the **Executing Agency (EA)**. GDE will be responsible for the overall implementation and compliance with loan assurances, the IEE, EMP and the EMoP.

436. GDE has established a **Project Management Unit (PMU)**. The PMU will be responsible, on behalf of GDE, for the day-to-day management and supervision of the project. The PMU will recruit the Project Management Consultant (PMC) and the MOEF-accredited environmental monitoring agency for environmental impact monitoring.

437. The PMU will have the overall responsibility to supervise the implementation of environmental mitigation and monitoring measures, ensure the contractors' compliance with environmental management requirements, and coordinate the Grievance Redress Mechanism (GRM) and report to ADB. The PMU will appoint an HSE & Safeguards Manager to coordinate and manage EMP implementation. He/she will be supported by a Health and Safety Assistant Manager, an Environmental Safeguard Assistance Manager, and a Government Relation and Social Safeguard Assistant Manager. In the Dieng field office, the PMU will establish a safeguard unit led by a HSE & Safeguards Superintendent, and staffed with a social Safeguards and PR Supervisor, a Health and Safety Supervisor, and an Environmental Safeguards Supervisor. To ensure that all contractors comply with the EMP provisions, the PMU with the help and technical support of the PMC (see below), will prepare specification clauses for incorporation into the bidding procedures: (i) a list of environmental management and monitoring requirements to be budgeted by the bidders in their proposals; (ii) environmental clauses for contractual terms and conditions; and (iii) the full EMP. The structure of the PMU is presented in Figure 9.1

438. To support the HSE staff, the PMU will recruit a project management consultant (PMC) who will act as the Owner's Engineer. The PMC will have one International Environment Specialist to be engaged for 23 person-months (PM) and two national Environment Specialists to work on the project for a total of 66 PM. These consultants will be responsible for undertaking the monitoring and reporting, on GDE's behalf, of the contractors' performance against the environment safeguards covenants included in the ADB Loan Documents. They will be prepare recommendations for change or improvement where deviations or non-compliance are identified. The environmental consultants in the PMC are expected to have a working knowledge and experience of the environmental guidelines and requirements of Indonesia and the ADB's SPS 2009.

439. In order to efficiently procure and manage contracts, GDE intends to bundle contracts for detailed engineering design, construction supervision, project implementation coordination, equipment supply, construction to the extent possible. The main contracts to be awarded by GDE in order to complete the project will include:

- Project Management Consulting (PMC) Contract for the specification, technical tender support and evaluation and oversight of engineering, fabrication, testing, construction and commissioning of power plants at both locations; FEED and DED for civil works; supervision of works, safeguards coordination, monitoring and reporting
- Engineer, Procure and Construct (EPC) Contracts for the design, supply, construction, commissioning and testing of power plants and SAGS facilities
- Various contracts for the supply of specialist drilling personnel including drilling engineers, drilling operating staff and rig geologists
- Supply of materials and construction of civil and enabling works
- Supply contracts for the delivery of wellheads, casing and drilling bits
- Bundled works packages for the supply and operation of drilling rigs
- Single works package covering rig services
- A range of smaller contracts associated with rig inspection, third party inspection and expediting and other miscellaneous activities (multiple contracts)

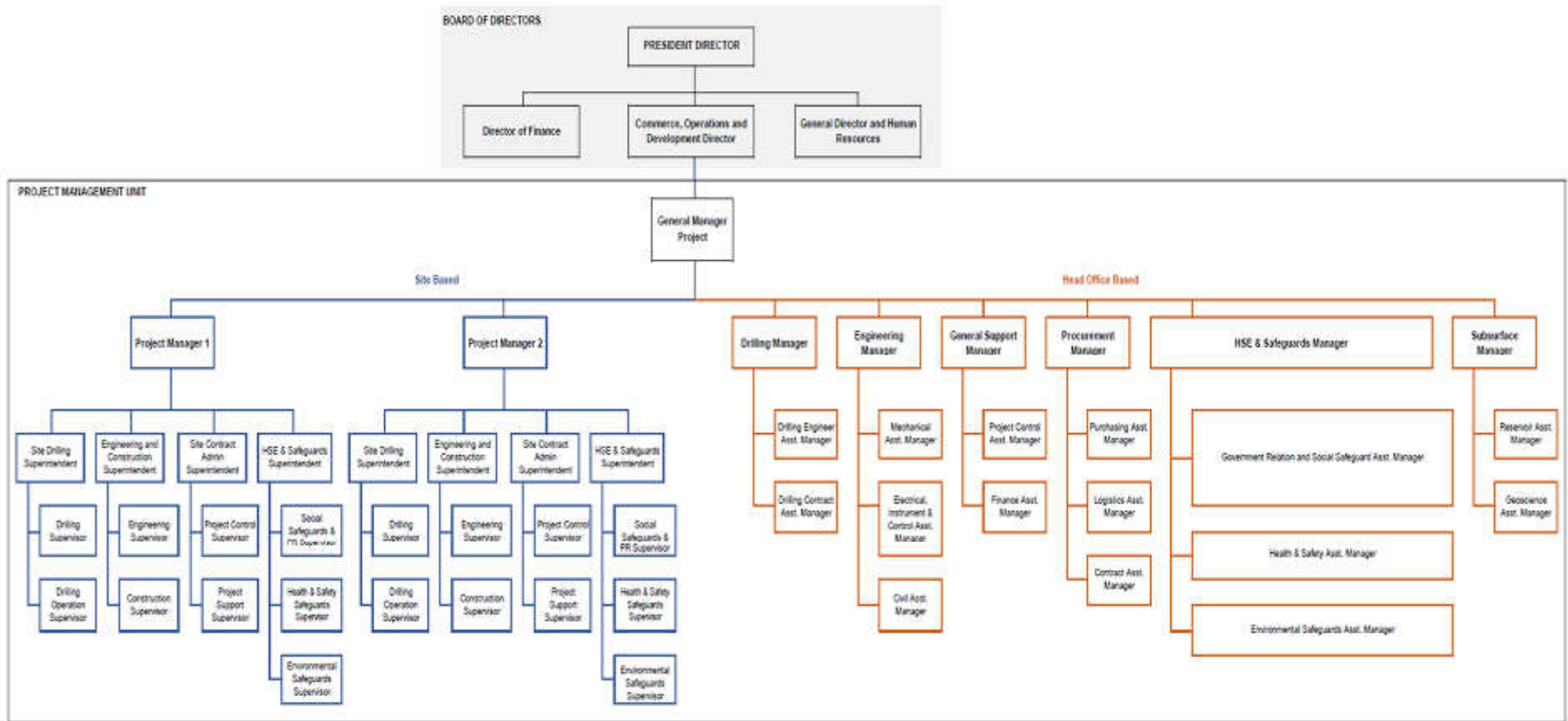


Figure 9.1: HSE and Safeguards Coordination Arrangements in the PMU

440. The key roles and responsibilities of the main project stakeholders are defined in Table 9.1. Detailed tasks for the PMC are defined in the Terms of Reference (TOR) under separate cover.

Table 9.1: Roles and Responsibilities During Implementation

Organization	Responsibilities (Environmental Safeguards)
GDE	<ul style="list-style-type: none"> Responsible for the overall implementation and compliance with ADB's SPS 2009, loan assurances, the IEEs and the EMP/EMoP.
PMU	<ul style="list-style-type: none"> Responsible, on behalf of GDE, for the day-to-day management and supervision of the project. Assign qualified staff in Head Office and the Site Offices to coordinate day-to-day environmental management, safety supervision and public relations of the project. Recruit the PMC and the MOEF-accredited environmental monitoring agency for environmental impact monitoring. Take the lead in construction site safety supervision and compliance enforcement for well drilling. Establish and coordinate the grievance redress mechanism (GRM). Prepare and submit to ADB semiannual environment safeguards monitoring reports.
PMC	<ul style="list-style-type: none"> Prepare FEED and technical specifications for Dieng and Patuha for power plant, SAGS and transmission interconnection to PLN terminal point (two separate EPC contracts for PP in Dieng and Pathua). Undertake feasibility study into opportunities for geothermal direct use at the Dieng Project. Support the PMU in the management of project health & safety, government liaison, local community liaison and communication activities and monitoring and reporting on project compliance with its environmental and social safeguards obligations (set out as ADB loan covenants). Update IEE and EMP to reflect FEED; ensure that relevant measures in the EMP and EMOP are incorporated into the tender documents and ensure these measures are implemented by EPC contractors as per their CEMP. Provide training to GDE (PMU) on environmental safeguards requirements as per the ADB SPS and the IEE/EMP. Assist and advise GDE during bid document preparation, tendering, evaluation of bids, contractor evaluation and contract negotiation, ensuring that environmental requirements are adequately reflected. Review and update, as needed, the IE and EMPs/EMOP to ensure that these reflect FEED. Responsible for overall project monitoring, ensure compliance to EHS policy of GDE, national and ADB environmental requirements, and obligations in the EMPs. Supervise safety management for the project (occupational and community safety). Conduct orientation to Contractors on environmental compliance to ADB and GOI requirements. Review and clear site-specific contractor EMPs (CEMPs). Prepare and submit monthly progress reports to GDE (including section on EHS) and semi-annual environmental monitoring reports to ADB until issuance of project completion report (PCR). Act as secretariat of the grievance redress mechanism (GRM). Review for completeness and adequacy O&M manuals, EHS procedures

Organization	Responsibilities (Environmental Safeguards)
	including EP&R procedures developed by the EPC contractors for Units 2 (for ISO14001 and SMK3 PP No.50/2012 certification). <ul style="list-style-type: none"> • Draft project completion report (PCR).
PMC—civil and enabling works	<ul style="list-style-type: none"> • Prepare DED for civil works, including new roads, refurbishment of existing roads, bridge inspections and upgrades, drilling water abstraction, reticulation and storage (Dieng only), drilling water reticulation to new well pads (Patuha), ensure that EMP requirements related to civil works are reflected in DED. • Support GDE in defining specification, technical tender and evaluation, and oversight of construction of civil works. • Ensure that safeguards requirements related to civil works are reflected in the detailed engineering design. • Daily supervision of construction works for civil works contract, • Ensuring that relevant measures on civil works in the EMPs and EMoP are implemented, covering environment and safety • Prepare/submit monthly reports on the status of project implementation to PMU.
SUCOFINDO (Environmental monitoring firm)	<ul style="list-style-type: none"> • Conduct environmental sampling for Dieng Unit 1 (operation), Dieng 2 (construction), and Dieng 1 & Dieng 2 (operation). • Prepare RPL for submission to MOEF.
EPC Contractor (for power plant and SAGS)	<ul style="list-style-type: none"> • Incorporate design-related environmental measures in DED • Prepare and secure approval of site-specific contractor EMP (CEMP) by PMC. • Implement mitigation measures identified in the CEMP. • Prepare/submit quarterly project progress reports to PMC. • Comply with the GDE HSE program; develop own program based on GDE and Contractor Safety Management System. • Develop O&M manuals, EHS procedures including EP&R protocols for new facilities in compliance with ISO14001. Provide training to GDE staff on EHS and EP&R procedures.
Civil Works, Drilling Contractors	<ul style="list-style-type: none"> • Prepare and secure approval of site-specific CEMP by PMC. • Implement mitigation measures identified in the CEMP. • Prepare/submit quarterly project progress reports to PMC.

9.3 Contractor Obligations Prior to Construction

Conduct of additional studies and surveys as part of DED

441. Following contract award but before approval of the DED, the EPC contractor must conduct a series of studies and surveys that shall inform final project design. These studies shall include, but may not be limited to, the following:

442. **Operational noise impact assessment.** The noise impact assessment conducted in the framework of this IEE confirmed general compliance with the relevant noise guideline values during operation, with temporary exceedance expected at some sensitive sites during well drilling

and venting. The EPC contractor will be required to conduct a comprehensive operational noise impact assessment reflecting DED, to demonstrate compliance with (i) maximum sound pressure levels at 1 m from any point on any item of equipment including valves (85 dBA); maximum sound pressure level at site boundary (70 dBA during daytime and 60 dBA during nighttime); and (iii) maximum sound pressure level at nearest sensitive receptor (55 dBA during daytime and 45 dBA during nighttime). This requirement shall be defined in the bid document for the EPC contract.

443. **Air quality modeling** in accordance with the configuration of equipment which will be used. The dispersion modeling shall indicate the maximum concentrations of pollutants of concern at site boundary and nearest sensitive receptors and demonstrate compliance with ambient H₂S level (28 µg/m³, 24-hr averaging time) and emission level (30 mg/Nm³).

444. **Operation hazard study**, including fire and explosion hazard assessment and fire safety and H₂S gas detection proposal (fire detection and alarm system design). The study should demonstrate that the facility will not result in unacceptable risks to facility operators and nearby communities during plant operation. The study shall be based on the rapid hazard identification (HAZID) and risk assessment conducted by an independent consulting firm (IJK Consultancy) in August 2019 (Appendix 8).

445. The results of the above studies shall be documented in easy-to-understand documents (short report, leaflet) and disseminated to potentially affected people through the project website, and as hard-copies at the site-office.

446. **Preparation of Contractor Plan.** Following contract award but before site works commence, the EPC contractor and the civil works and drilling contractors must produce their site-specific **contractor environmental management Plan (CEMP)**, to be reviewed and cleared by the PMC.

447. The CEMP shall will include, but not be limited to: (i) site regulations (covering security, occupational health and safety, access control, sanitation, medical care, fire prevention, emergency preparedness and response) to ensure worker and community safety, and prevent accidents during construction works; (ii) earthwork management plan; materials management plan, giving arrangements for supply of construction materials to avoid unnecessary stockpiling outside project site; (iii) waste management plan, for handling, transport, storage and disposal of solid and liquid wastes and hazardous materials at sites approved by local authorities; (iv) drainage plan, to ensure that construction works will not cause ponding or flooding at construction camp, temporary spoil disposal site, and other areas used for project-related activities and adjacent areas; (v) temporary traffic management plan, to control safe interaction of vehicular traffic and nearby communities during construction; (vi) noise and dust control plan, to minimize impacts to sensitive receptors (residential areas etc.) due to construction works, sourcing and transport of construction materials, and other project-related activities.

448. In the case of the EPC contractor, the CEMP will first be developed for the pre-construction and construction phase, but will eventually be adjusted to the operation phase (through the development of an facility-wide environmental management system EMS) including emergency preparedness and response (EP&R) system in compliance with ISO14001:2015.

449. **Securing Environmental Permits.** The PMU (with the support of the PMC) and/or the EPC contractor and the civil works and drilling contractors as applicable shall obtain all required environmental permits prior to construction. These may include but not be limited to: water use permit; permit for spoil disposal, concrete and asphalt batching plants, waste disposal sites, etc.

No works shall be allowed unless all permits are secured. Such confirmation should be provided by the PMC.

9.4 Impacts and Mitigation Measures

450. Potential environmental issues and impacts during the pre-construction, construction and operation phases, as identified in the IEE as well as corresponding mitigation measures designed to minimize the impacts are identified in the tables below. Mitigation includes two types of environmental measures:

- a. Measures that will permanently become part of the infrastructure such as fire detection and protection facilities, noise mitigation equipment, emission control and monitoring equipment are included in the contract costs, and are estimated to amount to 3% of the total investment costs.
- b. Temporary measures during the construction stage (e.g. dust suppression, use of quiet/low noise powered mechanical equipment, provision of sedimentation basins for suspended solids in construction site runoff, provision of sanitary facilities for construction workers, etc) will be included in the bidding document to ensure that EPC contractor includes them in their budgets. The implementation of these measures is estimated to cost 1% of the total investment costs.

451. The mitigation measures defined in the EMP will be (i) checked and where necessary re-designed by the PMC prior to construction and the EMP subsequently updated, as needed; (ii) incorporated into the CEMPs; and (iii) implemented by contractors under supervision of the PMC.

Table 9.2: Environmental Management Plan for Dieng Unit 2

Project Activity, Potential Environmental Impact	Mitigation/Enhancement Measures	Estimated Cost	Responsible Unit		
			Implementing Unit	Monitoring Unit	
A. Corrective Action for Unit 1 (i.e. those facilities classifying as associated existing facilities)					
Corrosion leading to pipe and wellhead leakage and rupture	A.1. Install visible warning signs for all personnel (Well Pad 30). A.2. Remove the unused tank using forklift and transport with truck to the backfill.	\$150	GDE	ADB	
Direct contact to process pipe surface leading to personal injury and/ or asset damage	A.3. Repair damaged insulation on the loop pipeline in gathering system, especially at location near volcanology Research Center and well pad 9.	\$110	GDE	ADB	
Nearby communities exposed to H2S from silencer, causing eye irritation, bad odor and headache.	A.4. Optimization of community counseling/ simulation to handling H2S exposure by GDE Peduli (CSR) or third party	\$1,500	GDE	ADB	
Brine pond overflow (well pads 30 and 10).	A.5. Pond Revitalization (Well pad 10 and Well Pad 30)	\$1,600	GDE	ADB	
Silica compounds around the pond and scaling pipe (well pads 7, 30)	A.6. Provide dedicated and protected place for collected silica from well pads 7 and 30 A.7. Include silica management in SOP of hazardous material waste management	\$16,000	GDE	ADB	
Sabotage, theft	A.8. Improve access control to existing wells pads 7, 9, 30 and 31 including fencing, gate and security guard.	\$1,600	GDE	ADB	
B. Front End Engineering Design/Detailed Engineering Design					
Surface water usage (drilling) – excessive use could lead to water use conflicts	B.1. Conduct additional water resources assessment to demonstrate no adverse impact on other water users during drilling works and PP operations B.2. Secure water permit prior to drilling work B.3. Design and install adequate water storage facilities for drilling	Part of DED (civil works)	PMC	PMU, ADB	
Detailed site investigations and risk assessments	B.4. Conduct detailed site investigation including flood risk assessment, storm drainage analysis. B.5. Conduct seismic hazard study and demonstrate that power plant structural design is seismically safe for anticipated seismic risks.	Included in scope of DED	EPC Contractor	PMC	
Consideration of operation phase impacts in the DED - Inadequate design may result in noise and air	B.6. Conduct detailed air dispersion modeling based on DED, confirming compliance with ambient H2S level (28µg/m³, 24-hr averaging time) and emission level (30 mg/Nm³)	Included in scope of DED	EPC Contractor	PMC	

Project Activity, Potential Environmental Impact	Mitigation/Enhancement Measures	Estimated Cost	Responsible Unit	
			Implementing Unit	Monitoring Unit
emission standards not being complied with. Fire and explosion risk due to inadequate design	B.7. Conduct detailed noise modeling based on DED, demonstrating compliance with IFC guideline values (55dB, 45dB, 3dB increment) B.8. Conduct risk assessment (fire & explosion) due to butane and pentane (for settlements in Karang Tengah and part of Bakal). The study shall be based on, and make use of, the HAZIP conducted by IJK Consultancy in August 2019 (Appendix 7) B.9. Disseminate results to potentially affected people.			
Integration of aesthetic elements in design	B.10. Incorporate landscape architecture elements into the DED to optimize harmonious integration of the infrastructure into the landscape.	Included in scope of DED	EPC Contractor	PMC
Communication, Grievance redress mechanism (GRM)	B.11. Establish GRM B.12. Establish information center. Produce leaflets, etc on project aspects (FAQ, IEE/EMP, GRM) B.13. Establish and maintain project website and/or social media presence	Included in GDE operating budget, PMC contract	PMU, PMC	GDE, ADB
Readiness of contractors to adhere to environmental management requirements	B.14. Develop and submit to PMC for approval a contractor environmental management plan (CEMP). The CEMP shall include (i) site regulations (covering security, occupational health and safety, access control, sanitation, medical care, fire prevention, emergency preparedness and response) to ensure worker and community safety, and prevent accidents during construction works; (ii) earthwork management plan; materials management plan, giving arrangements for supply of construction materials to avoid unnecessary stockpiling outside project site; (iii) waste management plan, for handling, transport, storage and disposal of solid and liquid wastes and hazardous materials at sites approved by local authorities; (iv) drainage plan, to ensure that construction works will not cause ponding or flooding at construction camp, temporary spoil disposal site, and other areas used for project-related activities and adjacent areas; (v) temporary traffic management plan, to control safe interaction of vehicular traffic and nearby communities during construction; (vi) noise and dust control plan, to minimize impacts to sensitive receptors (residential areas etc.) due to construction works, sourcing and transport of construction materials, and other project-related activities.	Included in scope of drilling, civil works and EPC contracts	PMC	PMU, ADB
C. Construction Phase				

Project Activity, Potential Environmental Impact	Mitigation/Enhancement Measures	Estimated Cost	Responsible Unit	
			Implementing Unit	Monitoring Unit
Power Plant and SAGS Construction				
Deconstruction/demolition of existing structures (old buildings at side of powerplant unit 2), with potential presence of asbestos-containing materials	C.1. Qualified 3 rd party (through PMC) to conduct a rapid assessment for the presence of asbestos as basis to develop a demolition plan C.2. Contractor to implement a demolition plan following health, safety, and environment (HSE) requirements of Indonesia, IFC-WB EHS General Guidelines, WHO, and ADB C.3. Demolition Plan to be approved by regulatory authorities and PMU C.4. Conduct environmental monitoring during demolition works	PMC, GDE corporate budget (demolition)	PMC, demolition contractor	PMU
Orientation of workers, contractors and staff on the responsibility for compliance to ADB and GOI requirements	C.5. Conduct routine environment and safety trainings for workers, including induction trainings and annual refresher trainings.	Included in scope of PMC	PMU, PMC	GDE
Generation of dust and vehicular emissions from earthworks and movement of vehicles to and from the construction sites (Site preparation, vegetation and land clearing for wells, power plant, access roads, and underground transmission line)	C.6. Regularly inspect and maintain heavy equipment C.7. Use of high-occupancy service vehicles to transport workers C.8. Emissions testing certificate of service vehicles will be required and monitored by PMU C.9. Install temporary fencing and/or enclosures at least 3-m high at construction sites C.10. Water will be sprayed daily in opened land areas or in other areas where dust is generated C.11. Stockyard will be covered during non-working hours C.12. Vehicles and equipment will not be allowed to sit and idle for more than 30 minutes C.13. Cover trucks that deliver dust-generating construction materials C.14. No burning of solid or liquid wastes and other combustible materials will be allowed within the construction sites and labor camps C.15. Provide PPE to operators of heavy equipment C.16. Limit noise-generating activities during daytime and provide temporary enclosures to stationary noise sources C.17. Drivers and operators must strictly follow road regulations particularly speed and excessive blowing of horns will not be allowed C.18. Provide ear plugs/muffs to workers exposed to high-level noise and rotate schedule of these workers every two hours	Included in scope of PMC-civil works, drilling and EPC	Contractors – EPC, Drilling, and PMC-Civil works	PMC, PMU
Potential transport-related and road accidents (movement of construction and service vehicles)	C.19. Contractor to assign staff continuously to manage traffic and to ensure public safety	Included in scope of PMC-civil works,	Contractors – EPC, Drilling,	PMC, PMU

Project Activity, Potential Environmental Impact	Mitigation/Enhancement Measures	Estimated Cost	Responsible Unit	
			Implementing Unit	Monitoring Unit
	C.20. Temporary public crossing points will be provided accommodating children, elderly, and persons with disabilities C.21. Clear and visible traffic warning signs will be installed, and adequate lighting will be provided.	drilling and EPC	and PMC-Civil works	
Generation of waste - Improper handling and disposal of waste generated may affect water quality and cause soil contamination	C.22. Contractor to prepare waste management plan, to be approved by PMC (as part of CEMP) C.23. Contractor to provide adequate garbage bins to all construction sites and workers' camps C.24. Heavy equipment and machinery workshops will be bunded or lined with impermeable material to prevent spills directly on land C.25. Contractor to provide oil-water separator for oily washings	Included in scope of PMC-civil works, drilling and EPC	Contractors – EPC, Drilling, and PMC-Civil works	PMC, PMU
Impact on biodiversity and precious ecology	C.26. Revegetate to improve aesthetics and create green buffer C.27. Land clearance and sourcing of construction materials will not take place within the IBA C.28. Sourcing of all construction materials such as wood, sand or gravel should be from outside of the IBA. C.29. Use of underground cable transmission line to completely avoid collision risks to migrating birds, showing GDE world-leading best-practice.	Included in scope of PMC-civil works, drilling and EPC	Contractors – EPC, Drilling, and PMC-Civil works	PMC, PMU
Occupational health and safety risks	C.30. Conduct trainings on safety and health hazards at least monthly C.31. Provide sanitary facilities and safe drinking water at the construction site and at the workers' camp C.32. Provide workers with PPEs such as goggles, safety shoes, etc. and its use will be mandatory C.33. Workers who will be assigned to high level noise-generating works will be rotated every two hours aside from wearing of PPEs. C.34. Conduct daily toolbox meetings to emphasize safety and health procedures C.35. Site Engineers to encourage brief exercise routine to highlight the value of health in the workplace C.36. Employees of contractor(s) will be required to have annual physical and medical examination. Health records will be kept confidential in the employee file. C.37. Install clear and visible warning signs as well as sufficient lighting C.38. Contractors will be required to follow relevant HSE SOPs of GDE and relevant IFC-EHS General Guidelines 2007 (Section 2)	Included in scope of PMC-civil works, drilling and EPC	Contractors – EPC, Drilling, and PMC-Civil works	PMC, PMU
Well Drilling and Development				

Project Activity, Potential Environmental Impact	Mitigation/Enhancement Measures	Estimated Cost	Responsible Unit	
			Implementing Unit	Monitoring Unit
Operation of drilling rig causing intermittent release of H ₂ S	C.39. Provide workers with masks C.40. Conduct ambient air quality monitoring quarterly C.41. Provide adequate ventilation in confined spaces	Included in scope of drilling contract	Drilling Contractor	PMC, PMU
Operation of drilling rig and equipment generating noise	C.42. Use of mobile rock muffler or silencer during well venting C.43. provide workers with earplug/muffs C.44. rotate workers every two hours to prevent discomfort C.45. Inform nearby communities of well drilling schedule	To be costed by drilling contractor	Drilling Contractor	PMC, PMU
Waste generated from drilling activities	C.46. Construct sump to hold produced water and waste drilling fluids C.47. The sumps should be lined with impermeable material to prevent soil and water contamination. C.48. Oil-water separator shall be provided for oily washings in the drilling equipment and trucks C.49. Provide garbage bins at basecamp C.50. Contractor to prepare waste management plan (as part of CEMP), approved by PMC	Included in scope of drilling contract	Drilling Contractor	PMC, PMU
Water requirements for drilling	C.51. Use of condensate from Unit 1 during dry season as primary source with an average flow rate of 30 L/s C.52. Use existing pipelines in Sikidang area to convey the condensate to Pad 24 where pond of about 1,800 m3 capacity is available but requires rehabilitation C.53. Reuse water-bentonite based mud to reduce water requirement C.54. Use aerated fluid drilling (clay-free) for the production-zone of the wells C.55. No water extraction during the dry season (July to September) so that irrigation of agricultural land by farmers will not be affected C.56. Construction of additional reservoir at new power plant site (Unit 2) of 5,000 m3 to supply peak water demand (including construction of power plant) C.57. Drilling services contractors to keep a record of daily operations to include volume of water used segregated by source of water C.58. Drill only 1 well at once (only 1 rig will be installed) C.59. Ensure sufficient flows (e-flows) remain in any stream where water abstraction occurs to minimize impacts to the freshwater snail, (<i>Gyraulus terraesacrae</i>).	Included in scope of drilling contract	Drilling Contractor	PMC, PMU
Discharge of steam during well testing - release of H ₂ S higher than	C.60. Workers assigned will be provided with PPE such as earplugs, mask and H ₂ S detector, and personal H ₂ S dosimeter with alarm system	Included in scope of	Drilling Contractor	PMC, PMU

Project Activity, Potential Environmental Impact	Mitigation/Enhancement Measures	Estimated Cost	Responsible Unit	
			Implementing Unit	Monitoring Unit
the occupational limit of 150 µg/m ³ set by WHO Elevated noise may affect hearing of workers during well testing	C.61. Install mobile rock muffler as silencer C.62. Use of SCBA's in the immediate area of well testing C.63. Conduct regular calibration of monitoring equipment to ensure accurate readings of H ₂ S C.64. Safety and medical personnel will be available on-site.	drilling contract		
Occupational health risks during drilling works	C.65. Base camp to be provided with sanitary facilities, wash areas, safe drinking water, and garbage bins to contain waste generated by workers C.66. Location of base camp shall not be close to settlements and water bodies C.67. Local hiring shall be a priority to minimize number of workers in base camp C.68. Fuel requirements in onsite fuel tanks and generators shall be located in designated contained areas to prevent leaks	Included in scope of drilling contract	Drilling Contractor	PMC, PMU
D. Operation Phase				
Release of H ₂ S at the cooling tower, affecting ambient air quality	D.1. Ducting of NCG to cooling tower to enhance dispersion D.2. Regular monitoring of H ₂ S emissions to ensure compliance to the 30 mg/Nm ³ limit for geothermal D.3. Regular monitoring of ambient H ₂ S level to ensure compliance to the 28 µg/m ³ limit D.4. Use operating condition (i.e., stack height, diameter, velocity, exit gas temperature, etc) that will meet emission and ambient level D.5. Conduct re-modeling of H ₂ S dispersion once data are available from DED D.6. Optimization of community counseling/simulation to handling H ₂ S exposure by GDE Peduli (CSR) or third party.	Included in the O&M budget of GDE	GDE Dieng	ADB, GDE HQ
Strengthen EMS, EP&R	D.7. Ensure ISO 14001:2015 accreditation for Units 2 prior to operations. D.8. Disseminate EP&R to nearby communities, include communities in emergency drills at least once a year.	Included in O&M costs	GDE Dieng, EPC contractor	GDE
Operation of turbine, cooling towers and other machinery - Increased noise level that may impair hearing	D.9. Noise –generating equipment like turbine is confined within buildings lined with sound absorbing walls. D.10. Workers assigned to high noise generating activities will be required to wear PPEs and will be rotated every two hours. D.11. Regular monitoring at site boundaries and nearest sensitive receptors to confirm compliance with WHO standard for day- and night-noise levels.	Included in the O&M budget of GDE	GDE Dieng	ADB, GDE HQ

Project Activity, Potential Environmental Impact	Mitigation/Enhancement Measures	Estimated Cost	Responsible Unit	
			Implementing Unit	Monitoring Unit
Storage and use of butane and iso-pentane Malfunction of control system and safety device causing rupture of storage tank of butane and iso-pentane	D.12. EPC contractor to use the most stringent international industry codes and standards in the design, construction, an installation of storage facilities D.13. EPC contractor to conduct detailed risk assessment as part of DED, and to consider installation of blast wall D.14. Install concrete bund walls to enclose the storage tanks D.15. Install leak or fire detection devices, fire control and alarm systems near the storage tanks D.16. Conduct training to workers on proper handling of these substances D.17. Conduct routine checks on the condition of the tanks, piping and gauges D.18. Install clear and visible warning signs within the proximity of the storage tanks D.19. Install lightning arrestors in strategic areas to prevent lightning strikes D.20. Conduct regular fire drills D.21. Observe good housekeeping at all times.	Cost estimate for blast wall is \$35,000 O&M costs included in O&M budget of GDE	GDE Dieng	ADB, GDE HQ
Maintenance of underground transmission line - Accidents and community safety risks along the underground transmission line from Karang Tengah to Sikunang (about 6.9 km)	D.22. Clear and visible markers will be installed to alert and guide local residents of the alignment D.23. Markers will be painted with reflective paints for visibility at night and during foggy days D.24. Only herbal vegetation and agricultural crops will be allowed to return to the ROW for safety reasons D.25. Trees, tall shrubs of plants with big roots will be prohibited along the ROW	Included in the O&M budget of GDE	GDE Dieng	ADB, GDE HQ

452. **Beyond Compliance:** GDE Dieng Unit 1 has been implementing an integrated environmental, and occupational health and safety (EHS) management system following the requirements of ISO 14001:2015 on Environmental Management System and the Government Regulation No. 50/2012 on Implementation of Occupational Health and Safety Management System. Once the operation of Unit 2 has been considered as already stable and reliable generating the expected output, GDE HSE and Safeguards Unit will work on getting similar accreditations to the ISO 14001 on environmental management system, OHSAS 1800 on health and safety reliable, and the SMK3 PP No.50/2012.

453. **An environmental monitoring plan (EMoP)** has been defined for the subproject in accordance with the Government of Indonesia and ADB requirements. The plan focuses on environmental compliance monitoring and environmental quality monitoring (ambient and emission monitoring e.g. air, water, soil, vibration and noise) during pre-construction, construction and operation. Environmental compliance monitoring will primarily be conducted by the PMC and environmental quality monitoring will be conducted by Sucofindo, a licensed monitoring entity. Monitoring arrangements defined for this project are described Table 9.3.

Table 9.3: Environmental Monitoring Plan for Dieng Unit 2

Key Activities/Anticipated Impacts	Monitoring Requirements	Monitoring Locations	Monitoring Period	Monitoring Responsibility	
				Implementation	Supervision
A. Corrective Action for Unit 1 (i.e. those facilities classifying as associated existing facilities)					
Improvements to existing facilities	Visual confirmation of necessary repairs/improvements to existing facilities as defined in measures A.1. to A.8.	Well pads 7, 9, 10, 30, 31	During DED and initial stage of construction	PMC	PMU
B. Front End Engineering Design/Detailed Engineering Design					
Detailed site investigation, Consideration of operation phase impacts in the DED	DED includes measures B.4. – B.10.	PP Unit 2	During DED	PMC	PMU
Communication, Grievance redress mechanism (GRM)	Working GRM, information center set up, updated GDE website, availability of project-related flyer and other social media (measures B.11. – B.13.)	PP Unit 2	Before start of construction works	PMU	GDE, ADB
Site-specific EMP prepared	Site-specific EMP prepared by contractors, reflecting requirements as defined in measure B.15.	N/A	Before start of construction works	PMC	PMU, ADB
C. Construction Phase					
Well Drilling and Development					
Air quality and noise - Increased noise and dust levels due to mobilization and demobilization of construction vehicles, equipment and materials for drilling	<ul style="list-style-type: none">Ocular inspection of road condition, temporary enclosures along the affected roadCertificate of service vehicles on emissions testing	Road intersection at Kejajar market and transport station, and Garung, Dieng Wetan and Dieng Kulon intersection	Quarterly during well development	PMC	PMU
	<ul style="list-style-type: none">Conduct regular ambient air quality monitoring: NO2, PM10, PM2.5Conduct ambient noise monitoring in settlements along the affected roads	Monitoring points defined in Figure 4.3 and Figure 4.5	Quarterly during well development	3 rd party monitoring agency	PMU
Community safety risks - Potential road accidents, damages, and traffic congestion due to mobilization and demobilization of	<ul style="list-style-type: none">Record of road accident, number and type of vehicles, and damages to road and associated infrastructure	Road intersection at Dieng Kulon, Bakal, Karang Tengah,	Once before start of mobilization	PMC	PMU

Key Activities/Anticipated Impacts	Monitoring Requirements	Monitoring Locations	Monitoring Period	Monitoring Responsibility	
				Implementation	Supervision
construction vehicles, equipment, and materials including drilling rigs	<ul style="list-style-type: none"> Ocular inspection of transportation routes to confirm adequacy of: temporary road crossings, traffic warning signs, Presence of designated staff to manage traffic Contractor's documents on payment for damages to affected people (if any). 	Kepakisan, Dieng Wetan	Quarterly during well development		
Generation of waste	<ul style="list-style-type: none"> Ocular inspection of availability of garbage bins; condition of location of temporary collection area; disposal method, MSDS, etc Drilling contractors' list of chemicals, paints, lubricants, etc. used 	Pad #7, Pad #9, Pad#10, Pad #30, Pad #31, Loc I	Once a month	PMC	PMU
Maintenance of sumps for drilling	<ul style="list-style-type: none"> Ocular inspection of working condition and maintenance 	Pad #7, Pad #9, Pad#10, Pad #30, Pad #31, Loc I	Twice a month	PMC	PMU
Occupational health and safety risks during well drilling and testing	<ul style="list-style-type: none"> Record of of workers that attended orientation on environmental requirements of GOI and ADB; workers attended HSE orientation and training (if any) Availability of emergency power and safety kit. 	Pad #7, Pad #9, Pad#10, Pad #30, Pad #31, Loc I	Start of drilling	PMC	PMU
	<ul style="list-style-type: none"> Ocular inspection of workers wearing PPE; Availability of PPE and first aid kits (hard hats, safety shoes, masks, H2S detectors and alarms, etc.); Presence and condition of sanitary facilities; Clear signs and safety warnings; Housekeeping at base camp 		Weekly		
Use of water for drilling activities, water quality	<ul style="list-style-type: none"> Record of water quantity used for drilling 	Tulis River, Cidolog River, Urang River (as relevant)	Daily	Drilling Contractor	PMC/PMU
	<ul style="list-style-type: none"> Ocular inspection of river condition (e.g., muddy) 	Upstream and downstream of	Weekly	PMC	PMU

Key Activities/Anticipated Impacts	Monitoring Requirements	Monitoring Locations	Monitoring Period	Monitoring Responsibility	
				Implementation	Supervision
		water extraction point at Tulis River, Cidolog River, Urang River (as relevant)			
	<ul style="list-style-type: none"> Surface water quality (pH, H₂S, BOD, COD) 	Upstream and downstream of water extraction point at Tulis River, Cidolog River, Urang River (as relevant)	Quarterly	3rd party monitoring agency	PMC/PMU
H ₂ S releases from well affecting ambient air quality and potential health effects to workers	<ul style="list-style-type: none"> Ambient H₂S monitoring 	Pad #7, Pad #9, Pad#10, Pad #30, Pad #31, Loc I	Quarterly	EPC Contractor	PMC/PMU
Power Plant and SAGS Construction					
Increased noise and dust levels due to construction works and movement of vehicles, equipment and materials for construction of power plant and SAGS	<ul style="list-style-type: none"> Ocular inspection of road condition, temporary enclosures along the affected road Certificate of service vehicles on emissions testing 	Road intersection at Kejajar market and transport station, and Garung, Dieng Wetan and Dieng Kulon intersection	Quarterly during well development	PMC	PMU
	<ul style="list-style-type: none"> Conduct regular ambient air quality monitoring: NO₂, PM₁₀, PM_{2.5} Conduct ambient noise monitoring in settlements along the affected roads 	Monitoring points defined in Figure 4.3 and Figure 4.5	Quarterly during well development	3rd party monitoring agency	PMU
Community safety risks -Potential road accidents, damages, and traffic congestion due to mobilization and demobilization of construction vehicles, equipment, and materials for construction of SAGS and power plant	<ul style="list-style-type: none"> Review EPC contractor's record of road accident, number and type of vehicles, and damages to road and associated infrastructure Record of road accident, number and type of vehicles, and damages to road and associated infrastructure Ocular inspection of transportation routes to confirm adequacy of: temporary road crossings, traffic 	Road intersection at Karang Tengah, Bakal, Dieng Kulon -	Quarterly during construction phase.	PMC	PMU

Key Activities/Anticipated Impacts	Monitoring Requirements	Monitoring Locations	Monitoring Period	Monitoring Responsibility	
				Implementation	Supervision
	warning signs, Presence of designated staff to manage traffic <ul style="list-style-type: none"> Contractor's documents on payment for damages to affected people (if any) 				
Occupational health and safety risks	<ul style="list-style-type: none"> Record of of workers that attended orientation on environmental requirements of GOI and ADB; workers attended HSE orientation and training (if any) Availability of emergency power and safety kit 	Construction site of Unit 2 and the 10 wellpads, along SAGS	Once at the start of construction then quarterly	PMC	PMU
	<ul style="list-style-type: none"> Ocular inspection of workers wearing PPE; Availability of PPE and first aid kits (hard hats, safety shoes, masks, H2S detectors and alarms, etc.); Presence and condition of sanitary facilities; Clear signs and safety warnings; Housekeeping at base camp Record of workers with annual physical and medical examination 		Quarterly		
Generation of waste	<ul style="list-style-type: none"> Ocular inspection of availability of garbage bins; condition of location of temporary collection area; disposal method, MSDS, etc EPC contractor's list of chemicals, paints, lubricants, etc. used 	Construction site of Unit 2 and the 10 wellpads	Monthly	PMC	PMU
C. Operation Phase					
H ₂ S emissions from Unit 2	<ul style="list-style-type: none"> Ambient air quality monitoring: H₂S and NH₃ H₂S emissions 	Ambient air quality in settlements – Karang Tengah, Kepakisan, Dieng Kulon, Bakal, Sikunang, Pranten;	Quarterly	3 rd Party environmental monitoring	PMU

Key Activities/Anticipated Impacts	Monitoring Requirements	Monitoring Locations	Monitoring Period	Monitoring Responsibility	
				Implementation	Supervision
		Monitoring points defined in Figure 4.3 Emissions – cooling towers, AFT in power plant, near ejectors			
	<ul style="list-style-type: none"> Rainwater quality testing – pH, SO₄, NO₃ 	Main gate of Unit 1 and Unit 2 Bakal, Karang Tengah, Dieng Kulon	Quarterly	3rd Party environmental monitoring	PMU
	<ul style="list-style-type: none"> Collect and analyze secondary data on public health profile acquired from the <i>Puskesmas</i>. 	Data collected from <i>Puskesmas</i> of Bakal, Dieng Kulon, Rancabali, and Pasirjambu subdistricts.	Semi-annual	3rd Party environmental monitoring	PMU
Maintenance of thermal pond	<ul style="list-style-type: none"> Water quality testing – temperature, pH, DO, TSS, Boron, dissolved H₂S, As, Cd, Pb, electric conductivity Water quality testing (springwater) – pH, Total coliform, electric conductivity, TSS, Cd, Pb, Boron, As Volume of water taken from Tulis and Cidolog River 	Pad #7, Pad #9, Pad#10, Pad #30, Pad #31, Loc I Community's wells at Ngandam, Sikunang, Karangsari, and Dieng Kulon	Quarterly	3rd Party environmental monitoring	PMU
Noise generated from Unit 2	Ambient noise levels (daytime and nighttime)	Ambient air quality in settlements – Kepakisan, Sikunang, Bakal, Dieng Kulon, Karang Tengah, Pranten (monitoring points defined in Figure 4.5)	Quarterly	3rd Party environmental monitoring	PMU

9.4.1 Reporting

454. The following reports related to the implementation of the EMP will be prepared and submitted to relevant agencies.

455. **Monthly progress reports by the Contractors (to the PMU, PMC).** The Contractors will submit monthly progress reports to the PMU and PMC. These reports will include reporting on EMP implementation performance, including EHS staffing, safety training conducted, grievances received, accidents/near-misses, and other parameters as requested by the PMC.

456. **Monthly progress reports by the PMC (to the PMU).** The PMC will submit monthly progress reports to the PMU. These reports shall include a section on EHS performance of contractors, CEMP implementation progress, grievances received, minor and major infringements, occupational accidents, and necessary corrective actions.

457. **Semi-annual environmental monitoring reports by PMC/PMU (to ADB).** The PMC, on behalf of the PMU, will prepare and submit semi-annual environmental monitoring reports to ADB for clearance and disclosure. The reports will follow the template prescribed by ADB. Semi-annual reporting shall continue after construction completion until the project completion report is issued.

9.4.2 Training, Capacity Building Plan

458. Under the project, capacity building will be through the PMC Contract where they will develop plans and programs or complete-on-the-job and seminar-based training designed to build the capacity of GDE on environmental management system, and the safeguards requirements of ADB based on SPS 2009.

459. At the Inception of the ADB loan, GDE staff will have an orientation of the ADB business processes and requirements during project implementation including environment. The PMU will have the opportunity to have an overview of what will be required for compliance.

460. During the construction phase, the HSE and Safeguards Unit and the Dieng Unit 2 site can participate in the ADB Safeguards Training on SPS 2009. PMC through the PMU will collaborate with the Indonesia Resident Mission on the schedule and other requirements. PMC will assess the training needs of GDE in developing the capacity building plan. Specific topics such as alternative dispute resolution, effective stakeholder engagement, monitoring EMF in power generation and transmission, and living safely close to a geothermal power plant may be useful. The PMC will coordinate with organizations like the Indonesia World Bank, WWF, IUCN, and other organizations mainstreaming safeguards to development projects. Partnership with the Indonesia Geothermal Association, a scientific and educational NGO promoting geothermal in Indonesia can provide a forum to share experiences and lessons learned in managing geothermal power plant.

461. Aside from these possible topics, GDE will build capacity on how to mainstream key gender considerations in the current environmental management system since its structure is governed by ISO 14001. A training on the innovations of ISO 14001 will be included in the capacity building plan including gender in community safety.

462. Training will not only cover GDE staff but will explore opportunities to involve selected members of the local communities in Karang Tengah, Dieng Kulon, Kepakisan, Sikunang,

Pranten, and Bakal. This community involvement may start by creating a Village Emergency Reponse Team (VERT). This team can have training on fire drills and familiarity with GDE HSE SOP on emergency preparedness and response system, search and rescue, community safety and, fire prevention.

9.4.3 Emergency Preparedness and Response Requirements During Construction

463. GDE has an emergency preparedness and response procedures based on the requirements of OHSAS 18001 (see Appendix 7) that EPC Contractor can refer to. The EPC Contractor, however, can prepare their own to be approved by PMU.

9.4.4 EMP Implementation Cost Estimates

464. Most of the mitigation measures proposed by this IEE consist of activities that are standard practices in most engineering construction sites (e.g. use of PPEs, prepare site-specific waste management plan, local traffic management plan, etc.). There is no mitigation measure specific to Dieng Unit 2 that was not implemented in other geothermal power generation project in Indonesia or in the world. Even the additional studies particularly the water study for well drilling would not be unusual for contractors who are used to working in similar geothermal power project. Thus, the mitigation measures specified in this EMP requires normal or good site-practice and applies construction standards to which an experienced international contractor would work as a matter of course. The costs of these mitigation measures will therefore be covered by the normal budget estimates for the contracts of drilling works and civil works, EPC, and GDE during operation. Table 9.3 shows a sample of the environmental checklist which can be revised to meet the requirements of the specific site.

465. As shown in Table 9.1, the implementation of environmental monitoring for Dieng Unit 1 (operation), Dieng 2 (construction), and Dieng Unit 1 and Dieng Unit 2 (operation) will be undertaken by a 3rd party provider accredited by the MOEF. The 3rd party provider will be engaged by GDE and the associated costs of environmental monitoring during project implementation will be borne by GDE under the O&M budget as they are required to submit semi-annual RKL-RPL implementation report to MOEF and other related authorities under the AMDAL.

466. Based on the outcome of the safety audit done by a 3rd party provider, the corrective measures identified for Dieng Unit 1 (Table 9.2) is estimated to cost approximately **\$21,000**. The environmental monitoring for the Unit 1 and Unit 2 is estimated approximately **\$43,000** per annum. Table 9.4 shows the estimated costs for corrective actions (i.e, Unit 1 and Unit 2) and semi-annual environmental monitoring.

Table 9.4: Cost Estimates for Corrective Actions and Environmental Monitoring

Description	Y1	Y2	Y3	Y4	Y5
<i>Corrective action on safety for Dieng Unit 1</i>					
Total costs	\$20,960	-	-	-	-
<i>Environmental Monitoring (3rd Party)^a</i>					
Laboratory sampling and analysis, data acquisition of secondary data, transport and car rental (Unit 1 and Unit 2)	\$43,000	\$43,000	\$43,000	\$43,000	\$43,000
TOTAL	\$63,960	\$43,000	\$43,000	\$43,000	\$43,000
^a covers both Unit 1 and Unit 2 as indicated in Table 1. Cost estimates were based on 2018 cost of 3 rd party environmental monitoring with adjustments.					

Table 9.5: Proposed Environmental Site Inspection and Monitoring Checklist

Name of Contractor	Location			
Inspection Date	Inspection Time			
Inspector	Weather at time of inspection:			

Items for Inspection	Y	N	NA	Remarks (i.e. problem observed, possible cause of non-compliance and/or proposed corrective action)
Site Office				
Site office established				
Contractor appointed an EHS supervisor				
EHS supervisor or designated person on-site				
Copies of EMP, contract document, and environmental clauses on-site				
Details of construction (i.e., name of contractor, duration of construction, emergency hotline, safety, etc.) disclosed on-site				
Details of grievance redress mechanism (i.e., contact person, complaints hotline, etc.) disclosed onsite				
Complete first aid kits on-site				
Photographs of before and after completion of work on board				
Incident register book on-site				
Complaint/visitor's comment book available				
Record of regular consultation of Contractor to University management and/or nearby residents to check if there are environmental concerns				
Any complaint filed with the contractor by staff and settlements				
Disturbed areas properly re-vegetate after completion of work				
Emergency Preparedness and Response				
Fire extinguishers/fire-fighting equipment properly maintained and not expired				
Fire escapes properly marked, clear, and not obstructed				
Emergency contacts available in case of any incident				
Accidents/incidents reported, reviewed, and corrective/preventive actions recorded				
Occupational Health and Safety				
Provision of labor and equipment shed				
Provision of hygiene and sanitation facilities and drinking water				
Use of personal protective equipment (PPEs)				
Installation materials and equipment storage				
Separate storage of fuel and lubricant				
Training on OHS, use of PPE, etc. done before construction works				
Clear danger and warning signs on-site for students, faculty and community				
Fencing of construction site and designation of security personnel				
Good housekeeping – site kept clean and tidy				

Items for Inspection	Y	N	NA	Remarks (i.e. problem observed, possible cause of non-compliance and/or proposed corrective action)
Containers properly labelled for ease of recycling/waste segregation				
Special facilities for female labor				
Bin for collecting garbage and food waste				
Air Quality				
Opened land and construction sites sprayed with water to minimize generation of dust				
Any evidence of excessive dust generation				
Stockpiles of dusty materials and dust-generation activities like handling of cement done in enclosed areas or sprayed with water				
Vehicles carrying dusty loads/materials covered or watered over before leaving the site				
Construction equipment well maintained (any black smoke or smoke belching observed)				
Demolition work areas watered				
Speed control measures applied (e.g. speed limit sign)				
Noise				
Evidence of excessive noise				
Any noise mitigation measure adopted (e.g. use noise barrier/enclosure)?				
Prohibition of using megaphone/whistle on-site				
Use of well-maintained equipment and vehicles only				
Water Quality				
Construction wastewater and domestic wastewater discharged to sewer systems or are on-site treatment facilities (septic tank)				
Wastewater discharged to soil				
Evidence of oil spill				
Chemicals properly stored and labelled				
Spill kits/sand /saw dust used for absorbing chemical spillage readily accessible				
Special facilities for female labor				
Construction waste/recyclable materials and general refuse removed off-site regularly				
Water pipe leakage and wastage prevented				

Reviewed by:

Name and signature _____
 Designation in PMU _____

Date _____

10 CONCLUSION AND RECOMMENDATION

467. GDE has embarked on Dieng Unit 2 to contribute in the goal of GOI to meet the 7% share of geothermal in the national energy mix by 2025, at the same time, supporting the commitment in COP21 to reduce GHG emissions at 29% by 2030. Implementation of Dieng Unit 2 will also help achieve the national target for 100% electrification by 2020.

468. Based on the national environmental requirements, Dieng Unit 2 is subject to AMDAL given the potential environmental impacts. However, the MOEF-approved ANDAL Addendum 2004 for Dieng covered the planned geothermal power generation capacity from the Dieng Geothermal Power Plant covered Unit 1, Unit 2, Unit 3, and Unit 4. However, Unit 2 will use a more advanced and efficient combined cycle power plant technology to increase the energy efficiency and to minimize the potential environmental impacts. Given this major change, another ANDAL Addendum is required as provided for by GR No. 27 of 2012. GDE is in the process of engaging an MOEF-accredited and certified environmental experts to prepare the Addendum. No works will be allowed to proceed unless the ANDAL Addendum is secured.

469. According to SPS 2009, Dieng Unit Unit 2 classifies as environment safeguard category B given that the potential environmental impacts are less adverse than a typical category A project. The impacts are site-specific, few if any of them irreversible, and in most cases mitigation measures can be more readily designed. This IEE was prepared based on the requirements of SPS 2009.

470. Additional studies were conducted as part of the IEE, including air quality and noise modeling, a critical habitat assessment including a survey of birds of pray, and a separate safety risk assessment that also reviewed GDE's current environmental management system and emergency preparedness and response procedures.

471. The IEE process contributed to improving project design and avoiding adverse impacts: (i) As a result of the critical habitat assessment, the design of the transmission line was changed from an overhead transmission line to an underground cable as this change will have no effect to migratory birds of conservation status. GDE accepted this design adjustment despite significantly higher construction costs; (ii) Unit 2 will use an air-cooled cooling system to minimize the use of water, avoiding adverse impacts on farming communities.

472. The noise assessment shows that there will be four stations where the noise level as per limits of GOI and the IFC-WB EHS Guidelines 2007 may not be reached during well development. However, such exceedances will be highly temporary during well drilling and venting. Mobile mufflers will be used as silencer to reduce noise levels during drilling. The air quality dispersion modeling study shows that there is a 0.6% probability that the $28 \mu\text{g}/\text{m}^3$ H_2S odour limit of the GOI will not be met in Karang Tengah and Dieng Kulon. The noise assessment and air quality study will be repeated and refined once more information becomes available from the detailed engineering design. A quantitative risk assessment, and review of the environmental management system (EMS) including GDE's emergency preparedness and response system (EPR) was conducted by an independent consulting firm. The assessment shows that GDE has generally robust EMS and EPR systems complying with SMK3, ISO 14001, and OHSAS 18001 but that some improvements are needed to strengthen safety aspects of Unit 1 operations, most

importantly access control to existing well pads. It was also recommended to develop a protocol to involve communities in emergency preparedness drills. Two public consultations were done confirming general public support for the project, as long as community concerns are adequately addressed. GDE committed to address key concerns and will continue to engage the communities on the safe and beneficial use of geothermal energy available in Dieng.

473. There are associated impacts during well development, construction, and operation of Dieng Unit 2 on noise, air quality, water use, and generation of wastes. However, these impacts can be readily mitigated through design, employing best available technology, good engineering construction methods, effective stakeholder engagement (as and when needed), compliance to EMP and environmental monitoring, and compliance to applicable regulations and standards on geothermal power plant operations, and environmental, health, and safety. GDE has a suite of HSE SOPs to provide guidance in implementing Dieng Unit 2 sustainably.