

Environmental Assessment Report

Environmental Impact Assessment
August 2009

INO: Sarulla Geothermal Power Generation Project

Prepared by Sarulla Operations Limited

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EXECUTIVE SUMMARY

Environmental Impact Statement (*Analisis Dampak Lingkungan Hidup = ANDAL*)
Environmental Management Plan (*Rencana Pengelolaan Lingkungan Hidup = RKL*)
Environmental Monitoring Plan (*Rencana Pemantauan Lingkungan Hidup = RPL*)

Development of Sarulla Geothermal Field and Power Plant of 330 MW Capacity

**North Tapanuli Regency,
North Sumatera Province**

August 2009

FOREWORD

SARULLA OPERATIONS LTD., (SOL) a consortium between PT MEDCO GEOPOWER SARULLA, ORSARULLA INC., SARULLA POWER ASSET LTD., and KYUDEN SARULLA PTE LTD, plans to develop Sarulla geothermal field and 330 MW power plant in Pahae Jae and Pahae Julu Districts of Tapanuli Utara Regency, Sumatera Utara Province.

The development of this project will bring positive impacts but on the other hand possibilities of negative impacts on physical-chemical components, biological components, and socio-economic, socio-cultural, and public health components.

AMDAL documents of Sarulla geothermal field development were approved in November 2005 by the Governor of Sumatera Utara. Considering (a) additional activities like production well operation and drilling; (b) changes in vapor and brine cooling system from water to air, which is more environmentally friendly; (c) constructions and operations of internal electricity transmission from Silangkitang (SIL) to Namora I Langit NIL; (d) changes of project proponent from PT PLN (Persero) to Sarulla Operations Ltd. (SOL), the 2005 AMDAL documents have been revised in order to continue the development of Sarulla geothermal field and power plant.

Following an approval of Term of Reference Document by the Environmental Impact Control Agency of North Sumatera Province No: 973/BPDL-SU/BTL/2008 on 8 August 2008, the Environmental Impact Statement (ANDAL), Environmental Management Plan (RKL) and Environmental Monitoring Plan (RPL) documents have been prepared. These documents have been prepared in accordance to Minister of Environment Decree No. 08 of 2006 regarding Guidance for Preparing Environmental Impact Assessment Documents.

Sarulla Operations Ltd. is committed to environment, health and safety (HSE) in conducting its activities. It is expected that this project will give benefits to the stakeholders, especially to local communities, local government, employees and its shareholders.

To those who have helped in the completions of ANDAL, RKL, and RPL documents, we express our gratitude.

Jakarta, June 2009

Project Proponent,
Sarulla Operations Ltd., (SOL)

Aries Pardjianto

Director

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CHAPTER I

INTRODUCTION

1.1 BACKGROUND

The development of Sarulla geothermal field and the construction of Sarulla power plant in Pahae Julu and Pahae Jae Districts, North Tapanuli Regency, North Sumatera Province commenced in 1993 by Unocal North Sumatera Geothermal (UNSG) that was officially awarded the right as contractor from PERTAMINA to develop Sarulla geothermal field and power plant. The owner of Sarulla Geothermal Working Area, through Joint Operation Contract (JOC) and direct right (through PERTAMINA), has access to sell electricity to PT. Perusahaan Listrik Negara (PLN, the State Utility Company) according to Energy Sales Contract (ESC). UNSG conducted a number of engineering technical and environmental studies covering the exploration, the development of Sarulla geothermal resources and the related infrastructures between 1994 to 1997. According to the JOC, all infrastructures and assets were properties of PERTAMINA and UNSG had the right to use them.

In the development of Sarulla geothermal field and power plant with a capacity of 330 MW, the Consortium and SOL signed a DOA with PT. PLN (*Persero*); a JOC with PERTAMINA Geothermal Energy; and an ESC¹ with PERTAMINA Geothermal Energy - and PT. PLN (*Persero*) on 14 December 2007.

SOL is the operation company established by the Consortium (PT MEDCO GEOPOWER SARULLA, ORSARULLA INC., SARULLA POWER ASSET LTD., and KYUDEN SARULLA Pte Ltd.) which plans to develop the geothermal field and the power plant in Sarulla, in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency, North Sumatera Province.

According to Article 24 of the Government Regulation No. 27 of 1999, the validity of an approved AMDAL documents is three (3) years. The AMDAL documents prepared by PT. PLN were approved by the Governor of North Sumatera on 21 November 2005. Considering (a) additional activities such as drilling and operation of production wells; (b) changes in cooling system for steam and brine, from water to air which is more environmentally friendly; (c) construction and operation of internal electricity transmission from SIL to NIL; (d) changes of proponent from PT. PLN (*Persero*) to SOL. In order to accommodate the above changes, the 2005 AMDAL documents have been

¹ PT. Pertamina Geothermal Energy is a subsidiary of Pertamina which manages geothermal business sector.

revised to continue with the plan to develop Sarulla geothermal field and power plant.

1.2 PROJECT DESCRIPTION

1.2.1 SOL project location

The development of Sarulla geothermal field and the construction of Sarulla power plant is located in Pahae Julu and Pahae Jae Districts, North Tapanuli Regency, North Sumatera Province (See **Map I-1**). In relation to Regency Spatial Plan, the Government of North Tapanuli Regency issued North Tapanuli Regency Regulation No. 19 of 1994 regarding North Tapanuli Regency spatial planning, which designated the districts of Pahae Jae, Tarutung and Pahae Julu as areas of geothermal natural resources.

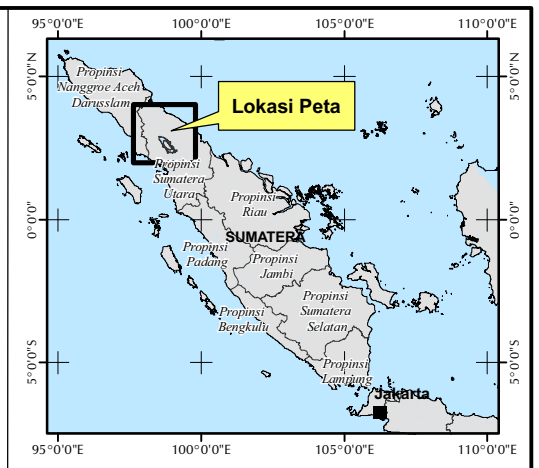
1.2.2 Stages of project activity

The development of Sarulla geothermal field and 330 MW power plant includes the following activities:

- The development of Sarulla geothermal field i.e. Silangkitang (SIL) field and Namora I Langit (NIL) field;
- The construction and operation of 330 MW geothermal power plant, one unit at SIL and two units at NIL each with a capacity of 110 MW;
- The construction of 150 kV (high voltage) transmission line from Silangkitang field (SIL 1) to Namora I Langit field (NIL 1), with an approximate distance of 15 km.

Drilling activity for new production and injection wells will mostly take place at the existing well pads previously developed by the former project proponent. Some will be in new areas, such as in NIL. A majority of the development areas at NIL are farmland whilst at NIL are a combination of farmland and mixed forest.

The power plant locations for both SIL and NIL will be at plantation areas whereby the power plant at SIL will be located at community plantation areas whilst at the power plants at NIL will be at mixed plantation areas. SIL is situated approximately 500 meter from the nearest residential area whilst NIL is located far from a residential area. The project schedule for the development of Sarulla 330 MW power plant at SIL and NIL is displayed in **Table I-1**.



LEGENDA
Legend

- Ibu Kota Provinsi
Provincial Capital
- Ibu Kota Kabupaten/Kotamadya
Regency Capital/Municipality
- Ibu Kota Kecamatan dll
District Capital
- ▲ Gunung
Mountain
- Jalan
Road
- +— Rel Kereta Api
Railway
- +—+— Batas administrasi Provinsi
Province Administrative Boundary
- +—+— Batas Administratif Kabupaten
Regency Administrative Boundary
- +—+— Sungai
River

N

0 12.5 25 50 Kilometers

Sumber (Source) :
 Peta Rupa Bumi Indonesia (BAKOSURTANAL)
 The Shuttle Radar Topography Mission (SRTM), Resolusi 90 meter
 Universal Transverse Mercator (UTM), Zona 47 Utara, Datum Reference WGS 84

RINGKASAN EKSEKUTIF EXECUTIVE SUMMARY			
LOKASI PROYEK PENGEMBANGAN PANAS BUMI DAN PEMBANGUNAN PLTP SARULLA PROJECT LOCATION OF GEOTHERMAL POWER PLANT			
Skala Scale	1:300.000	Digambar Oleh Drawn By	GGG
Peta Map	I - 1	Diperiksa Oleh Proofreader	ABU
Tanggal Revisi Revision Date	25/07/08	Digabung Oleh Compilation	ERM

Table I-1 *Project schedule for the development of Sarulla 330 MW power plant at Silangkitang (SIL) and Namora I Langit (NIL)*

Activity	Time	Month					
	0	+10	+20	+30	+40	+50	>50
Preconstruction							
Construction							
SIL							
NIL 1							
NIL 2							
Operation							
SIL							
NIL 1							
NIL 2							

1.2.2.1 *Pre-construction stage*

1.2.2.1.1 *The development of Sarulla geothermal field*

This activity consists of preliminary study, detailed construction design, and land acquisition.

1.2.2.1.2 *Construction of geothermal power plant*

SOL will construct, operate and maintain a power plant with a total installed capacity of 330 MW. To fulfill the capacity, three unit power plants will be constructed where each will generate approximately 110 MW. The first unit will be built at SIL and another two units at NIL.

1. Preliminary study

This stage consists of three phases of power plant construction, one plant at SIL and two plants at NIL. Each power plant has a capacity of 110 MW (a total of 330MW) and each consists of one Ormat Geothermal Combined Cycle Unit (GCCU) unit, plus two Ormat Energy Converters (Brine OEC) units. A GCCU consists of one backpressure steam turbine generator and four Bottoming OECs.

2. Land acquisition

The land required for the power plant construction is already taken into account in the land acquisition process for the development of geothermal field and construction of access roads. In the construction plan, one power plant unit will be built at SIL and two units will be built at NIL where each will have a capacity of 110 MW (a total of 330 MW). The amount of land required for the power plants is approximately 7 ha for SIL and 12 ha for NIL (a total of 19 ha).

1.2.2.1.3 *Transmissin line construction between SIL and NIL*

1. Land acquisition

The process will be conducted using direct negotiations and agreements between land owners and SOL, facilitated by the government of North Tapanuli Regency. The purchased land will be used as platforms for transmission tower and not for transmission lines. Approximately 40 towers will be built with 3 towers per 1 km. It is estimated that each transmission tower will require 225 m², and therefore the total of land required for 40 towers is 2 ha.

1.2.2.2 *Construction stage*

1.2.2.2.1 *Sarulla geothermal field development*

1. Workforce recruitment

Workforce mobilization is to be undertaken at the same time as mobilization of equipment and materials. The workforce mobilization will be done gradually through constructions companies and SOL's own effort. Mobilization will take place at well pads during the construction stage which involves transfer of drilling equipment from one well location to the next as the drilling progresses. During this transfer, an increase of vehicle movements between well locations is expected.

The number of workforce who will be involved in the development of Sarulla geothermal field is approximately 100 – 150. This consists of 5% for administration, 30- 40% as supervisors and technicians, and 55-65 % as staff.

2. Mobilization of equipment and materials

Construction activities start with mobilization of equipment and materials that will be used in the project. Mobilization is plan to use existing access roads i.e. materials will be transported inland from Belawan Port to the project area Sumatera Highways.

3. Land preparation

The land preparation consists of two main activities i.e. vegetation clearing, and land clearance and removal.

4. Civil engineering construction

The civil engineering construction includes two main activities i.e. improvements of Sumatera Highways roads and bridges within the project location, and construction of well pad foundation.

5. Access roads

Construction of access roads involves 3 locations as follows:

- To strengthen and widen access roads to NIL;
- Access roads to SIL and employee housing area;
- Access roads to each well pad.

6. Well pads preparation

In the development of Sarulla geothermal field, the development and operation of power plant, 10 wells and 25 wells at SIL and NIL respectively will be drilled, as production and reinjection wells (**Table I-2**).

It is assumed that the success rate of production wells is 90%, and therefore the number of drilling failure is 1 for SIL and 2 for NIL.

Table I-2 Numbers of wells to be drilled at SIL and NIL

Well pad	Numbers of wells			Output Capacity Target (Mwe)	Average Well Capacity (Mwe/Well)
	Existing	New	Total		
SIL					
Production	2	3 (included 1 failure)	5	110	27.5
Reinjection	0	5	5	For total liquid to be injected	-
NIL					
Production	0	19 (included 2 failures)	19	220	12.9
Reinjection	0	6	6	For total liquid to be injected	-

Source: West JEC Table 3.1.1-1

Note: Numbers of wells may change subject to well testing results

7. Production well pads

Four production well pads are initially required to develop these areas where three of the well pads are already exist i.e. SIL 1, NIL 1 and NIL 2. The new proposed well pad is NIL WJ-P1, located about 1 km south east from NIL 1.

8. Reinjection well pads

Four reinjection well pads (2 pads at SIL and 2 pads at NIL) are required for the start-up wells where three are existing pads (SIL 1, SIL 2 and NIL 3). These pads will be located far from the production area to minimize the risk of reservoir cooling. One new proposed pad, WJ-R1, will be built at NIL.

9. Constructions of temporary facilities – worker accommodation area and working area

Contractor will provide all temporary facilities, including offices, worker accommodation area, storage materials area, and working area.

10. Disposal area

All unused or excess materials during construction activity will be collected and deposited in a landfill by the contractor.

11. Temporary drainage during site preparation

Temporary drainage system will be provided by the contractor during the site preparation construction work. The system will include temporary ditches, collection pits and sedimentation basins for mud water treatment.

12. Drilling and production test

Drilling is conducted to prepare production and reinjection wells. It is anticipated that 35 wells will be drilled at SIL and NIL. The drilling will use a conventional drilling rig, equipped with outpouring prevention equipment and H₂S detection tool, to drill up to 3,500 meter.

The drilling process will use water based mud to prevent the borehole walls from caving during drilling. At certain depths, well casing will be installed to prevent caving of the borehole, and to prevent leakage from or to soil and rock formations. After the drilling is completed, wellhead will be equipped with tools to control fluid flow rate from the well. The chemicals used will have MSDS (Material Safety Data Sheet).

The objective of the drilling activity is to prepare production and re-injection wells.

1.2.2.2.2 *Power plant construction*

1. Workforce recruitment

A total of 1,400 employees will be needed during the peak of the construction stage.

2. Mobilization of equipment and materials

Heavy equipment will be transported from Medan using the existing road network i.e. Sumatera Highways (Medan–Tarutung).

Whenever possible, materials used in this project will be supplied locally. Materials will be transported inland by trucks.

3. Land preparation for power plant and employee residential area

The sites will be prepared by removing all the top soil, grading and leveling to the required elevations. At NIL, an inventory of trees already undertaken, and the land clearing, including tree cutting and leveling, will be carried out according to the applicable regulations. Details of the land required for power plant sites and employee residential area are shown below:

- SIL

Area : about 265m x 300m

Elevation : 537m above sea level

- NIL

Area : about 460m x 300m

Elevation : 830m above sea level

- Employee residential area

Area : about 2 ha

4. Power plant construction

The construction stage will include civil engineering work and building construction. Civil engineering work will be undertaken along the roads towards the direction of the power plant and other supporting facilities. Gravel and sand required will be taken from a quarry with license from the authority. The civil engineering work includes:

- Land preparation, covering road construction towards the power plant, power plants construction, steam separator facility and other supporting facilities;
- Improvements of existing and new access roads to the power plant locations and well pads;
- Constructions of the power plant office buildings and supporting facilities.

The construction will be designed and built according to guidelines for earthquake resistance buildings (SNI 03-1726-2002) or other international standards.

5. Mechanical and electrical constructions

Mechanical construction includes installations of power plant equipment such as: steam turbine generator and supporting tools, OEC units, condenser with air cooler, overhead crane, etc.

Electrical construction includes assembly and installation of generator, control system and relays, transformers, switchgears, and lighting facility.

Other activities include painting and installation of pipe insulator. The insulator will be used to stabilize the temperature and pressure of steam and brine from wells to power plants.

1.2.2.2.3 *Construction of transmission line between SIL and NIL*

1. Workforce recruitment

Workforce is needed to mobilize equipment and materials, land preparation, and installation of transmission. The number of workforce required at the peak of this activity is between 200-300 people.

2. Mobilization of equipment and materials

The mobilization will be using existing road network. Whenever possible, materials used in this project will be supplied locally. If not, the materials will be supplied from the nearest area. Materials will be transported inland by trucks using the route Medan – Tarutung – Sarulla towards storage facility around project location.

3. Penyiapan Lahan

The land preparation consists of two main activities i.e. vegetation clearing, and land clearance and removal. Land will be prepared not for the whole transmission line (15 km) but at certain locations i.e. areas for transmission towers. Equipment required will include wood cutting machine, machete, and typical heavy equipment.

4. Installation of transmission tower

This activity consists of constructions of towers for the High Voltage Transmission Line. The towers will be constructed at certain distances. The transmission line with capacity of 150 kV and approximate length of 15 km will connect SIL and NIL.

Interconnection point between PLN and Sarulla power plants will be at the dead end tower at NIL.

1.2.2.3 *Operation stage*

1.2.2.3.1 *The development of Sarulla geothermal field*

The operation stage is to operate the steam production system to generate electricity. The system consists of production sources, well heads, safety valves, pipe lines, separators and brine accumulator units, and control tools.

Geothermal fluid from reservoir will be channeled to separators in order to separate steam and brine at an optimum pressure. Both steam and brine are used to generate electricity at 330 MW capacity. In an emergency situation, a brine storage pond will be used as a temporary reservoir before pumping the brine to re-injection well.

1.2.2.3.2 *Power plant operation stage*

Steam from SIL and NIL is exploited from a geothermal reservoir. The steam is separated into steam and brine which will then sent to the power plants to generate electricity. Before the steam is sent to the turbine, it is purified in a separator to maintain a dryness of $\pm 99.95\%$ and non condensable gas (NCG) contents of $\pm 2.1\%$ weight in SIL and $\pm 3.7\%$ in NIL.

Activities in this stage includes workforce recruitment, and operations of steam turbine and condenser.

1.2.2.3.3 *Operation of transmission line from SIL to NIL*

Electricity generated by SIL and NIL power plants will be transmitted to transmission lines T/L 150Kv which is part of the North Sumatera subsystem grid constructed by PLN close to NIL. The transmission line between the PLN substation and NIL power plant will have a voltage of 150 KV, two (2) circuits with sufficient capacity per circuit to transmit electricity from Sarulla power plant units.

The main activities are workforce recruitment and transmission line facility maintenance.

1.2.2.4 *Post-operation stage*

Post-operation stage will be conducted at the end of the project cycle. This stage will be conducted by a project contractor.

1.2.2.4.1 *Closure of production and reinjection wells*

Deactivation of wells will be conducted according to wells closure procedure. Reclamation of the wells area will be conducted by re-planting grass and plants. The process is as follows:

- Replenishing of wells – wells will be closed with cement (a minimum of 30 m depth). The cement layer will be placed on top of casing shoe. Another layer of cement will be put on top of it. Mud with similar density as the cement, which is also used as drilling mud, will fill in the gap between the two cement layers;
- Production and reinjection wells closure will follow the procedure for permanent well closure.

1.2.2.4.2 *Deactivation of pipelines and supporting facilities*

Following completion of the operation stage, all power plants will not be used anymore. The deactivation process will be as follows:

- Pipelines, pumps, and supporting facilities, will be dismantled, loaded onto a truck and sold to a scrap metal buyer, or disposed in a designated disposal area;
- Well pads will be replanted with grass and local plants.

1.2.2.4.3 *Deactivation of geothermal power plants*

Following completion of the operation stage, all power plants will not be used anymore. The deactivation process will be as follows:

- All equipment that can be utilized will be dismantled and re-used in other projects within or outside of Indonesia. Non-usable equipment will be sold;
- The remaining buildings and equipment will be demolished. The debris will be sold or disposed in a designated disposal area;
- Power plant locations will be rehabilitated through reclamation scheme by planting grass and local plants;
- Land will be sold if it is not used anymore;
- SOL workforce release will follow the applicable law and regulations.

1.2.2.4.4 *Transmission line dismantling procedure*

The transmission line will be dismantled and the location will be cleared of any remaining building materials. All equipment which can still be reused will be dismantled and transferred to other projects. Reclamation will be performed if needed.

1.2.3 *Alternative in AMDAL study*

The locations for and the technology used in the development of Sarulla geothermal field and power plant were already determined and therefore, no alternatives need to be assessed in this AMDAL study. Project sites, both in

SIL and NIL, will be developed to utilize the geothermal resources to generate electricity. The electricity generated will be distributed to PLN grid.

1.3 PROJECT PROPONENT

Company : SARULLA OPERATIONS Ltd. (SOL)

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Person in charge : Aries Pardjimanto

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CHAPTER II

ENVIRONMENTAL SIGNIFICANT IMPACTS

2.1 *PRE-CONSTRUCTION STAGE*

In pre-construction stage, the project activity with negative significant impacts i.e. land ownership and occupancy, and community unrest will be land acquisition.

It is anticipated that the potential causes of community unrest are inadequate compensation or because the company approach is not in accordance with local customs.

2.2 *CONSTRUCTION STAGE*

2.2.1 *Geophysical and chemical components*

Air quality. Impact on air quality, i.e. increases of H₂S concentrations during construction stage, will be due to well drilling and production test.

Noise. Impact on noise level will be due to the following activities: mobilization of equipment and materials, well drilling and production test, and power plant construction. The noise level caused by these activities will be higher than the baseline noise level. Such impacts may disturb the community in the vicinity of the project area.

Ground traffic disturbance. Impact on traffic disturbance will be caused by mobilization of equipment and materials to and from project area.

2.2.2 *Socio-economic, socio-cultural and public health components*

Impacted socio-economic, socio-cultural and public health components will be job opportunities, business opportunities, community income, and community unrest. The activity workforce recruitment will have positive impacts towards like job and business opportunities, and community income.

Workforce recruitment during the construction stage between 1 to 2 year period will require approximately 1,410 workers. An increased in employment will create business opportunities for the nearby community especially in relation to the construction workers' needs such as accommodation, food stalls and restaurants, grocery stores, and transportation service. An increased in job opportunities, business opportunities will increase community income either directly as SOL

employees or contractors, and entrepreneurs supporting the construction activity.

2.3 OPERATION STAGE

2.3.1 *Geophysical and chemical components*

Impacted physical-chemical components will be air quality (H₂S) and noise.

The operation of power plant may cause significant negative impacts on air quality mainly H₂S. Steam from SIL and NIL is exploited from a geothermal reservoir. The steam is separated into steam and brine which will then be sent to the power plants to generate electricity. Before the steam is sent to the turbine, it is purified in a separator to maintain a dryness of $\pm 99.95\%$ and NCG contents of $\pm 2.1\%$ weight in SIL and $\pm 3.7\%$ in NIL. The NCG consists of H₂S.

Noise level from this activity will increase. At a monitoring station near the project area, it is predicted that the noise level will exceed 55 dBA, which is still below the noise standard for industrial area of 70 dBA.

2.3.2 *Socio-economic, socio-cultural and public health components*

Impacted socio-economic, socio-cultural and public health components in the operation stage will be job opportunities, business opportunities, community income, and community unrest as the negative impact due to workforce recruitment. The number of workforce recruited during the operation stage will be lower than during the construction stage as the operation stage will require special skilled workers.

The recruitment process will potentially cause community unrest. Another cause of community unrest will be the feeling amongst local community that the number of migrant workers is higher than of local workers.

2.4 POST-OPERATION STAGE

2.4.1 *Socio-economic, socio-cultural and public health components*

Impacted socio-economic, socio-cultural and public health components in the post-operation stage will be job opportunities, business opportunities, community income, and community unrest. Workers will be released from their jobs and this will reduce business opportunities, which will have further impact on community income.

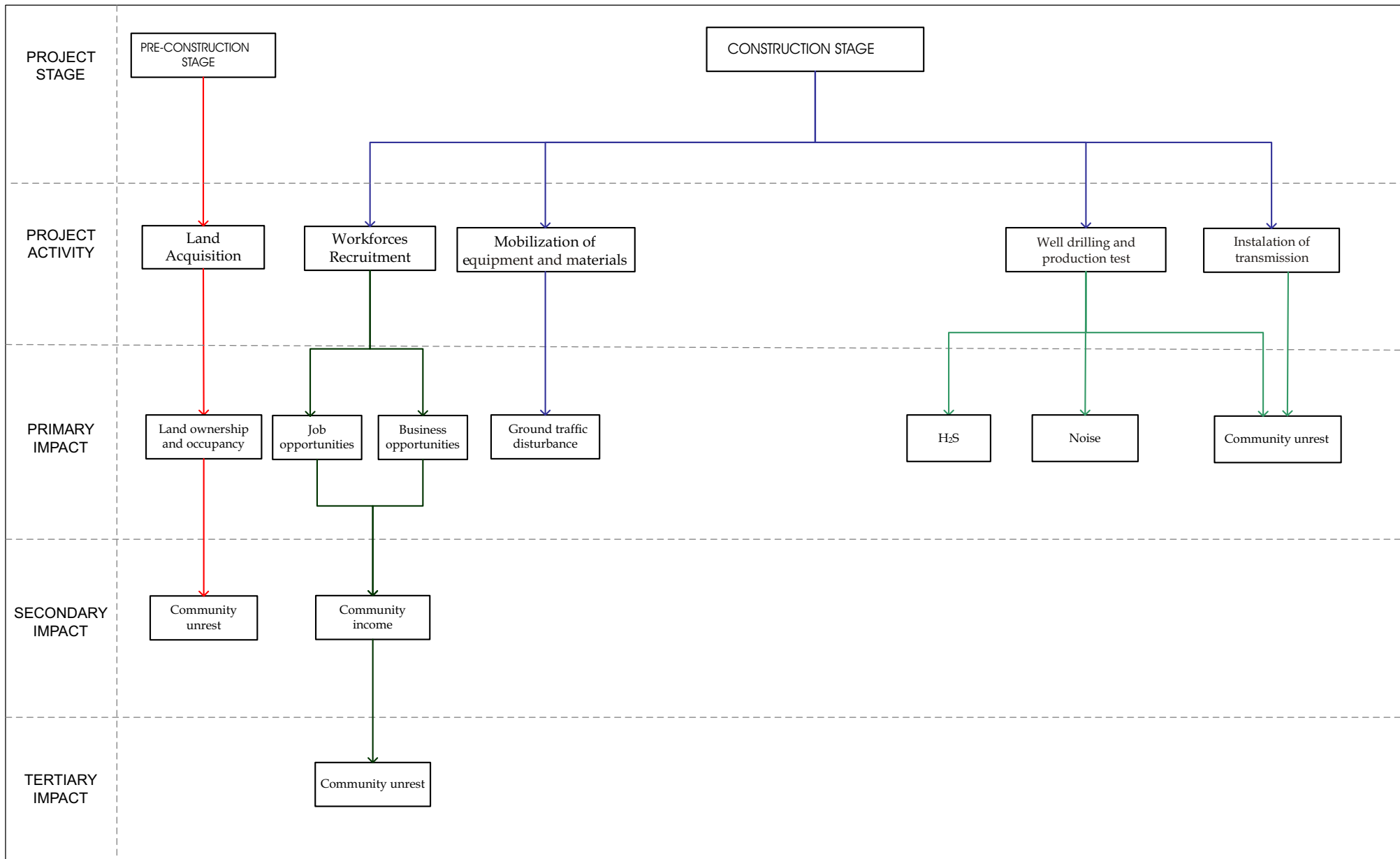


Figure II-1 Evaluation of significant impacts of sarulla project : pre-construction and construction stages

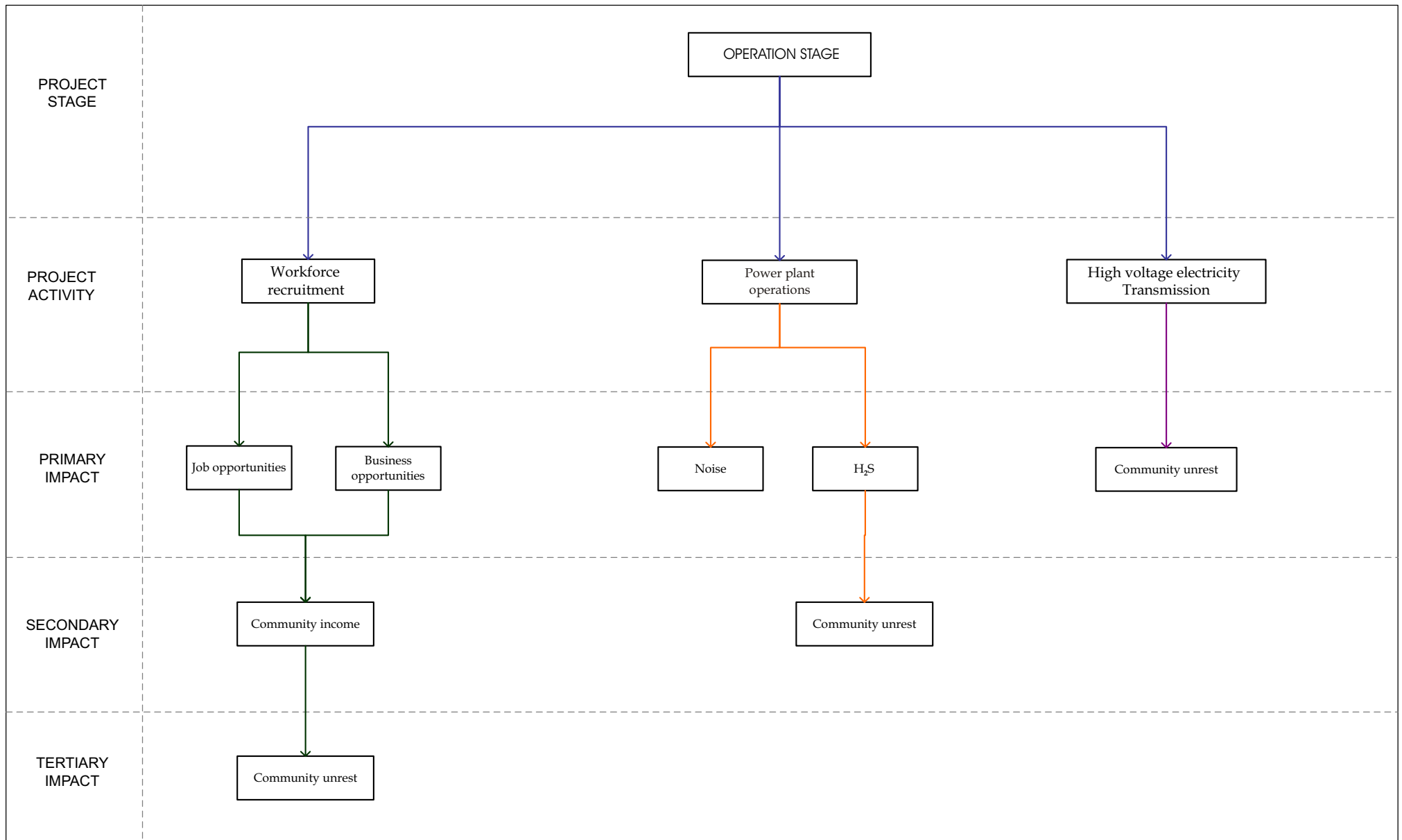


Figure II-2 Evaluation of significant impacts of sarulla project : operation stage

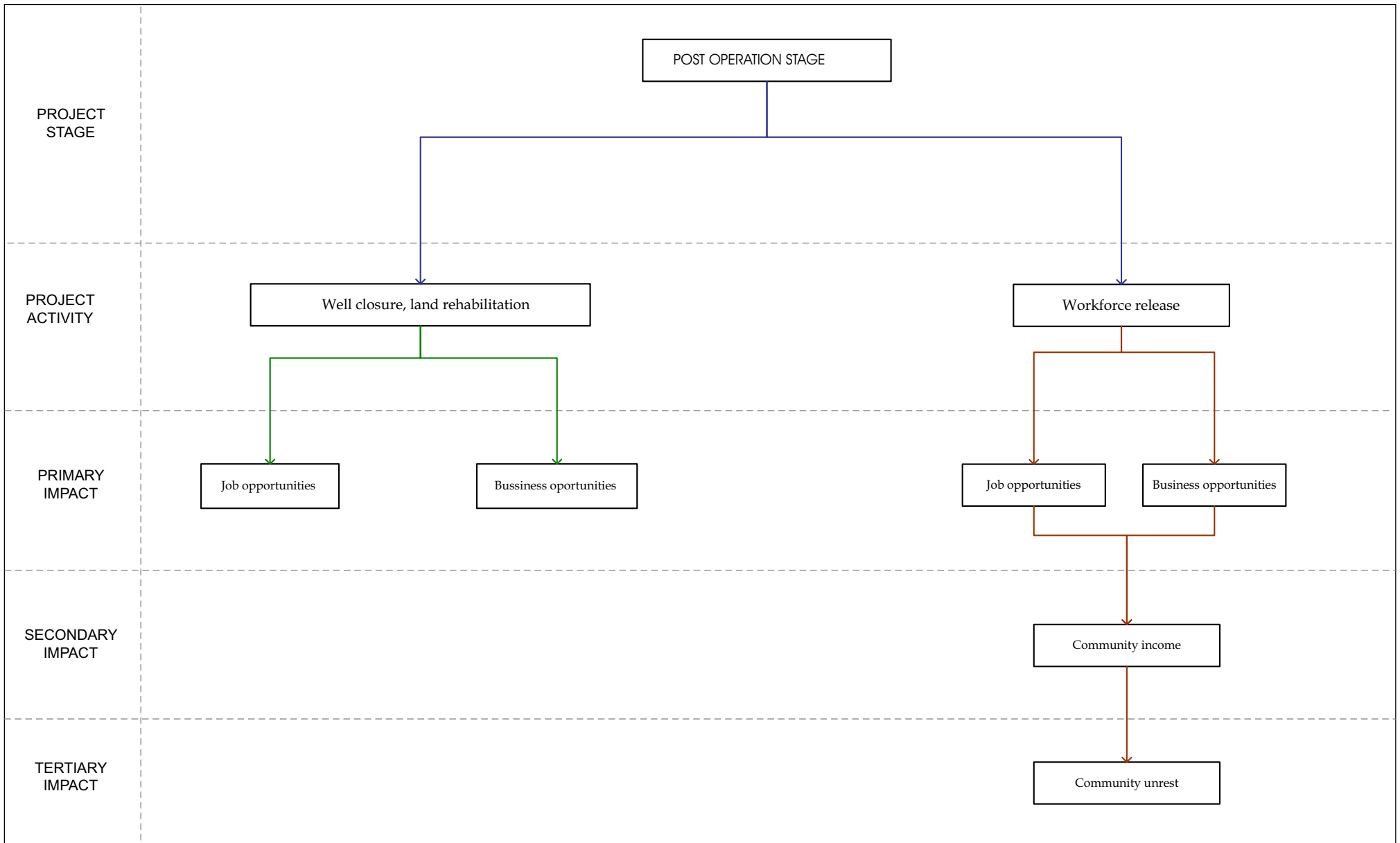


Figure II-3 Evaluation of significant impacts of Sarulla Project : post-operations stage

CHAPTER III

ENVIRONMENTAL MANAGEMENT PLAN AND ENVIRONMENTAL MONITORING PLAN

Activities of developing Sarulla geothermal field and power plant of 330 MW capacity in North Tapanuli Regency, North Sumatera Province are predicted to cause impacts on environmental aspects i.e. geophysical and chemical, biological, socio-economic, socio-cultural and public health. Therefore, an Environmental Management Plan (*Rencana Pengelolaan Lingkungan* = RKL) and an Environmental Monitoring Plan (*Rencana Pemantauan Lingkungan* = RPL) have been prepared as guidelines in managing and monitoring the environment.

The predicted significant impacts on those environmental aspects will be managed by the following approaches: preventative and mitigation for negative impacts, and development for positive impacts.

The next step is to undertake environmental monitoring to understand the success rate of the environmental management plan implemented.

Details Environmental Management Plan and Environmental Monitoring Plan towards the predicted environmental impacts due to the project activities can be viewed in the Environmental Management Plan and Environmental Monitoring Plan documents. The matrixes are presented in **Table III-1**.

Table III-1 Environmental Management Plan and Environmental Monitoring Plan Summary Matrix

Environmental Component/ Activity	Source of Significant Impact	Environmental Management Plan		Environmental Monitoring Plan			
		Significant Impact Parameter	Environmental Management Plan	Significant Impact Parameter	Data Collection and Analysis	Environmental Monitoring Location	Monitoring Period and Frequency
A. Pre-construction stage							
Socio-economic, socio-cultural, and public health components							
Land ownership and occupancy	Land acquisition	Land ownership	<ul style="list-style-type: none"> Prepare a project plan and to coordinate with relevant authorities on areas which will be acquired Undertake public consultation for each land acquisition activity Persuasively approach land owners/users in order to obtain information on land ownership status and size of land Investigate, ensure and record the land ownership information Coordinate with relevant local authorities (National Land Agency North Tapanuli Regency, Head of District (camat) and village heads (kepala desa) during the land acquisition process Obtain mutual agreements between the project proponent and land owners on the values and forms of compensation towards land and vegetation acquisitions in accordance with applicable laws and regulations 	Area and lay out of the land required by SOL	<ul style="list-style-type: none"> To calculate the amount of land required for the project To acquire data on land ownership, area, legal status of the land to be acquired and from the National Land Agency (BPN) of North Tapanuli Regency To create a map of land ownership in collaboration with the BPN of North Tapanuli Regency 	The development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	During the pre-construction stage
Community unrest	Land acquisition	Community unrest	<ul style="list-style-type: none"> Prepare a work plan consisting of land acquisition mechanism, land compensation system and monitoring plan Consult and disseminate accurate information regarding land acquisition activities Carry out land acquisition activities fairly and openly 	Community unrest	To collect data and to record complaints arising from the land acquisition process	Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	During the pre-construction stage

Environmental Component/ Activity	Source of Significant Impact	Environmental Management Plan		Environmental Monitoring Plan			
		Significant Impact Parameter	Environmental Management Plan	Significant Impact Parameter	Data Collection and Analysis	Environmental Monitoring Location	Monitoring Period and Frequency
B. Construction stage							
Geophysical and chemical components							
H₂S	Well drilling and production testing	H ₂ S concentrations in ambient air	<ul style="list-style-type: none"> Secure well locations and limit access for local communities Workers nearby well locations must be equipped with PPE (Personal Protective Equipment) Production test locations will be equipped with H₂S monitoring equipment Maintenance of construction vehicles Reduce vehicles speed to a maximum of 40 km/hour Put 'Do Not Enter' signs for unauthorized personnel during the drilling and test production Evacuate personnel and residents around well locations if H₂S concentration is exceeded If based on monitoring results the H₂S concentration exceeds the threshold, production wells will be reduced to ensure achievement of H₂S concentration standard 	H ₂ S concentrations in ambient air	Measurement of H ₂ S concentrations in ambient air using H ₂ S monitoring equipment according to Indonesian National Standard (SNI)	Well locations and villages around the well locations	Once a week during well drilling and production testing
Noise	<ul style="list-style-type: none"> Mobilization of equipment and materials Well drilling and production testing Power plant construction 	Noise	<ul style="list-style-type: none"> Maintenance of construction vehicles Reduce vehicles speed to a maximum of 40 km/hour Install silencer to reduce noise Workers nearby production test well to use ear muff Put 'Do Not Enter' signs for unauthorized personnel during the drilling Plant trees with wide canopies to reduce noise level Consultation with communities close to the project location 	Noise level	Measurement of noise levels in ambient air using equipment according to Indonesian National Standard (SNI)	<ul style="list-style-type: none"> Well locations Villages around the well locations 	Once a week during production testing
Socio-economic, socio-cultural, and public health components							
Job opportunities	Workforce recruitment	Job opportunities	<ul style="list-style-type: none"> Provide job opportunities for local communities who fulfill company's requirements and qualifications Encourage contractors to hire as many local workers as possible 	Job opportunities	To record the numbers, percentages, areas of origin of SOL and its contractors employees using available employee data from SOL and its contractors	<ul style="list-style-type: none"> Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency SOL office at project location 	Once a year during construction stage

Environmental Component/ Activity	Source of Significant Impact	Environmental Management Plan		Environmental Monitoring Plan			
		Significant Impact Parameter	Environmental Management Plan	Significant Impact Parameter	Data Collection and Analysis	Environmental Monitoring Location	Monitoring Period and Frequency
Business opportunities	Construction activities	Business opportunities	Provide opportunities for local businesses to participate in the provision of goods and services	Business opportunities	<ul style="list-style-type: none"> To collect data on purchases of goods and services carried out by SOL and its contractors, and contracts that SOL awarded to local companies To collect data on the growth of local businesses before, during and after construction stage 	North Tapanuli Regency	Once a year during construction stage
Community income	Construction activities	Community income	<ul style="list-style-type: none"> Provide job opportunities for local communities who fulfill company's requirements and qualifications Provide opportunities for local businesses to participate in the provision of goods and services 	Community income	To collect community income data from local agencies	Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	Once a year during construction stage
Community unrest	<ul style="list-style-type: none"> Workforce recruitment Well drilling and production testing Installation of transmission network 	Community unrest	<ul style="list-style-type: none"> Prepare a work plan on local workforce recruitment during drilling and installation of transmission network Consult and disseminate accurate information on workforce recruitment and its requirements fairly and openly Public consultation on the drilling plan Public consultation on the plan to install transmission network 	Community unrest	To record complaints regarding the use of local workers, well drilling and production testing, and installation of transmission network	Villages in the vicinity of project area (Sibaganding, Lumban Jaean, Simataniari, Silangkitang, Sigurung-gurung, Pardomuan Nainggolan, Pardamean Nainggolan)	Once a year during construction stage
Transportation	Mobilization of equipment and materials	Ground traffic disruption	<ul style="list-style-type: none"> Installation and maintenance of traffic signals Cover trucks properly to avoid spillage of materials onto the road Collaborate with professional contractors in the provision of transportation services for equipment and materials Routine and scheduled maintenance for heavy duty vehicles Routine road inspections with relevant government authorities to ensure safe and good road conditions, and that local communities' activities do not endanger traffic conditions Operation of heavy duty vehicles during non-peak hours 	Ground traffic disruption	To record data on the number of traffic accidents experienced by SOL staff and its contractors, and to record accidents along the roads accessed by project vehicles	Roads accessed by project vehicles in North Tapanuli Regency	Once a year during construction stage

Environmental Component/ Activity	Source of Significant Impact	Environmental Management Plan		Environmental Monitoring Plan			
		Significant Impact Parameter	Environmental Management Plan	Significant Impact Parameter	Data Collection and Analysis	Environmental Monitoring Location	Monitoring Period and Frequency
C. Operation stage							
Geophysical and chemical components							
H₂S	Power plant operation	H ₂ S concentrations in ambient air	<ul style="list-style-type: none"> If the H₂S concentration at the monitoring locations exceed the odor quality standard of 0.02 ppm, emission of H₂S from power plant will be controlled using technologies such as LO-CAT sulfur recovery unit until the concentration meets the odor quality standard Secure power plant location and limit access for local communities Workers working in the surrounding power plant area must be equipped with PPE (Personal Protective Equipment) Equip power plant with H₂S monitoring equipment 	H ₂ S concentrations in ambient air	Measurement of H ₂ S concentrations in ambient air using H ₂ S monitoring equipment according to Indonesian National Standard (SNI)	<ul style="list-style-type: none"> Well locations Power plant locations Villages around well drilling and production testing locations 	<ul style="list-style-type: none"> Well locations: once every three months Power plant locations: once every three months Villages around well drilling and production testing locations: once every three months
Noise	Power plant operation	Noise level	<ul style="list-style-type: none"> Workers in and around power plant to use ear muff Install silencer to reduce noise Plant trees with wide canopies to reduce noise level 	Noise level	Measurement of noise levels in ambient air using equipment according to Indonesian National Standard (SNI)	<ul style="list-style-type: none"> Well locations Power plant locations Villages around well drilling and production testing locations 	<ul style="list-style-type: none"> Well locations: once every three months during operation stage (24 hours monitoring) Power plant locations: once every three months during operation stage (24 hours monitoring) Villages around well drilling and production testing locations: once every three months during operation stage (24 hours monitoring)
Socio-economic, socio-cultural, and public health components							
Job opportunities	Workforce recruitment	Job opportunities	<ul style="list-style-type: none"> Provide job opportunities for local communities who fulfill company's requirements and qualification Encourage contractors to hire as many local workers as possible 	Job opportunities	To record the numbers, percentages, areas of origin of SOL and its contractors employees using available employee data from SOL and its contractors	<ul style="list-style-type: none"> Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency SOL office at project location 	Once a year during operation stage
Business opportunities	Operation activities	Business opportunities	<ul style="list-style-type: none"> Provide opportunities for local businesses to participate in the provision of goods and services Provide guidance for local businesses in order to fulfill company's standards 	Business opportunities	<ul style="list-style-type: none"> To collect data on purchases of goods and services carried out by SOL and its contractors, and contracts that SOL awarded to local companies To collect data on the growth of local businesses before, during and after construction period 	<ul style="list-style-type: none"> North Tapanuli Regency SOL office at project location 	Once a year during operation stage
Community income	Operation activities	Community income	<ul style="list-style-type: none"> Provide job opportunities for local communities who fulfill company's requirements and qualifications Provide opportunities for local workers to grow and expand 	Community income	To collect community income data from local agencies	<ul style="list-style-type: none"> Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency SOL office at project location 	Once a year during construction stage

Environmental Component/ Activity	Source of Significant Impact	Environmental Management Plan		Environmental Monitoring Plan			
		Significant Impact Parameter	Environmental Management Plan	Significant Impact Parameter	Data Collection and Analysis	Environmental Monitoring Location	Monitoring Period and Frequency
Community unrest	<ul style="list-style-type: none"> Workforce recruitment Operation of transmission network 	Community unrest	<ul style="list-style-type: none"> Prepare a work plan on local workforce recruitment in fair and open ways Public consultation on the operation of transmission network 	Community unrest	To record complaints regarding the use of local workers, well drilling and production testing, and operation of transmission network	<ul style="list-style-type: none"> Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency SOL office at project location 	Once a year during construction period
D. Other monitoring							
Solid and liquid waste monitoring							
Surface water quality	Drilling wells, sump pit, well production (during production test) which potentially produce both B3 and non-B3 wastes	Heavy metals, hazardous and toxic (B3) wastes	<p>Domestic solid waste:</p> <ul style="list-style-type: none"> Solid waste disposal to landfills <p>Liquid waste:</p> <ul style="list-style-type: none"> Liquid domestic waste water treatment from all project activities in domestic waste water treatment plant Condensate and brine generated during the power plant production testing and operational to be injected into reinjection wells Construction of sump pit that is coated with waterproof layer. Collected water in the sump pit, used in the drilling process as drilling mud component to be returned into the wells <p>B3 waste:</p> <ul style="list-style-type: none"> Fragments in the drilling mud to be stored in the sump pit Drilling mud to be stored in the sump pit Ensure that equipment and materials purchased by SOL do not contain PCBs, asbestos, ozone depleting substances and other prohibited materials according to relevant regulations Neutralize and securely store used lead acid batteries Collection of used oil, which then stored into drums and handed over to registered B3 management companies for further process Installation of secondary containments around flammable and hazardous materials as required Regular training on B3 waste management for employees 	Solid waste: types and quantities of waste collected, transported, disposed to landfills, and recycled Domestic liquid waste effluent: BOD, COD, TSS, and pH Types and quantities of hazardous and toxic (B3) wastes Spillage: types and quantities of spillage	<ul style="list-style-type: none"> To measure the quantities of solid waste generated by counting the number of trucks coming in and out of waste disposal area To sample, prepare and analyze water samples from domestic wastewater treatment plant outlets according to SOL protocols (which are based on Indonesian National Standards (SNI)) and to measure pH, conductivity, and <i>in situ</i> To monitor the implementation of standard operational procedures (SOP) for oil spill prevention To monitor the correct implementation of SOP for B3 wastes handling and disposal To carry out TCLP Test for drilling sludge, slurry waste and drill powder 	<ul style="list-style-type: none"> Domestic solid waste disposal area Domestic wastewater treatment plant location Well locations (sump pit and slurry disposal) Community wells at SIL and NIL Batang Toru River 	<ul style="list-style-type: none"> Solid waste: each time solid waste is being disposed Domestic wastewater treatment plant: once a month Well locations: during and after drilling

Environmental Component/ Activity	Source of Significant Impact	Environmental Management Plan		Environmental Monitoring Plan			
		Significant Impact Parameter	Environmental Management Plan	Significant Impact Parameter	Data Collection and Analysis	Environmental Monitoring Location	Monitoring Period and Frequency
<i>Community Development Programs</i>							
Provision of education services and facilities	Increased demands for education services and facilities	Provision of education services and facilities for local communities	Cooperation with relevant stakeholders in formal education and training to improve the qualities of local community resources	Provision of education services and facilities for local communities	To evaluate the effectiveness of all projects funded by SOL	Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	Once a year during the implementation of community development program
Provision of public health services	Increased demands for health services and facilities	Provision of public health services and facilities	Cooperation with relevant stakeholders in health services	Provision of public health services and facilities	To evaluate the effectiveness of all projects funded by SOL	<ul style="list-style-type: none"> Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency Public health centers in the vicinity of the project area 	Once a year during the implementation of community development program
Initiatives for improving farming and agriculture cultivation techniques	<ul style="list-style-type: none"> Limited knowledge on agricultural commodities with high economic values amongst young farmers Low level of interest on agricultural activities amongst younger generation Shortage of agriculture production Limited high quality agricultural production facilities Limited skills in using agricultural machineries amongst farmers 	Agriculture productivity in Pahe Jae and Pahe Julu Districts, North Tapanuli Regency	Cooperation with relevant stakeholders in local agriculture	Agriculture productivity in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	To evaluate the effectiveness of all projects funded by SOL	Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	Once a year during the implementation of community development program
Local business opportunities	<ul style="list-style-type: none"> Level of local community participation integrally and equally in local business opportunities Level of local community's business skill Availability of access to sources of funding and capitals 	Local communities' participation level in various economic activities	<ul style="list-style-type: none"> Encourage the use and purchase of local products and services by SOL and its contractors Provide assistance in training and opportunities to participate in local business activities Increase local communities' involvement in entrepreneurship through local business activities Cooperation with local communities to improve the qualities of local goods and services 	Local communities' participation level in various economic activities	<ul style="list-style-type: none"> To collect data on purchases of goods and services carried out by SOL and its contractors, and contracts that SOL awarded to local companies To record the number of economic facilities managed by the local communities To record data on economic and business development initiatives undertaken by SOL 	Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	Once a year during the implementation of community development program
Provision of public infrastructures	<ul style="list-style-type: none"> Rapid growth and development rates Local communities' increased demands for public services 	Local communities' needs and demands for public services	<ul style="list-style-type: none"> Cooperation with local governments to determine public infrastructures to be provided Encourage and assist local governments to develop its own social service initiatives 	Local communities' needs and demands for public services	To collect data on the availability of public infrastructures and evaluate the effectiveness of all projects funded by SOL	Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	Once a year during the implementation of community development program

Environmental Component/ Activity	Source of Significant Impact	Environmental Management Plan		Environmental Monitoring Plan			
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Cultural preservation	Increasing presence of modern society and its associated infrastructures and materials	Changes in traditional, cultural values and customs	Support local ethnics program s and activities, preserve local culture including traditional activities (dances), cultural festivals, seminars and conferences, books and monographs on language, history, sociology and local anthropology	Traditional activities, cultural festivals, books and monographs on language, history, sociology and local anthropology	<ul style="list-style-type: none"> To document and report on programs and activities of local ethnic groups Cultural preservation, including traditional activities (dancing), cultural festivals, seminars and conferences, books and monographs on language, history, sociology and local anthropology 	Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	Once a year during the implementation of community development program
Awareness of SOL activities	Misinformation circulating in the local communities concerning SOL activities	Accuracy and completeness of information about SOL activities within the local communities	Regular information dissemination related to SOL activities to community leaders and local government	Accuracy and completeness of information about SOL activities within the local communities	<ul style="list-style-type: none"> To review the discussions with employees and community leaders about information dissemination to employees and the local communities To review the discussions with local government about information dissemination to the local communities 	Villages in the vicinity of the development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	Once every three years during operational stage
E. Post-operation stage							
Socio-economic, socio-cultural, and public health components							
Job opportunities	Employee release	Community unrest	Consultation with workers on the plan to release employees	Job opportunities	To collect community income data from local agencies	Villages in the vicinity of project area (Sibaganding, Lumban Jaean, Simataniari, Silangkitang, Sigurung-gurung, Pardomuan Nainggolan, Pardamean Nainggolan)	Once during post -operation stage
Business opportunities	Completion of the operation stage	Business opportunities	Public consultation on the completion of project activities	Community income	Documenting complaints from local communities regarding employee release		
Community income	Completion of the operation stage	Community income	<ul style="list-style-type: none"> Consultation with workers on the plan to release employees Provide adequate compensation to workers in accordance with applicable regulations Public consultation on the completion of project activities 	Community unrest	To record the numbers, percentages, areas of origin of SOL and its contractors employees using available employee data from SOL and its contractors	The development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	During the post-operation stage
Community unrest	Workforce release	Community unrest	<ul style="list-style-type: none"> Prepare a work plan on workforce release Consultation with workers on the plan to release employees 	Job opportunities	To collect community income data from local agencies	The development of Sarulla geothermal field and power plant project area in Pahae Jae and Pahae Julu Districts, North Tapanuli Regency	Once in post-operation stage