REPUBLIC OF KENYA

Kenya Electricity Generating Company Limited (KenGen)

Republic of Kenya
Supplementary Feasibility Study for Olkaria V Geothermal Power Plant Additional Unit Project

FINAL REPORT

Pre-release version

February 2026

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

West Japan Engineering Consultants, Inc.

KY
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Supplementary Feasibility Study for Olkaria V Geothermal Power Plant Additional Unit Project

Final Report

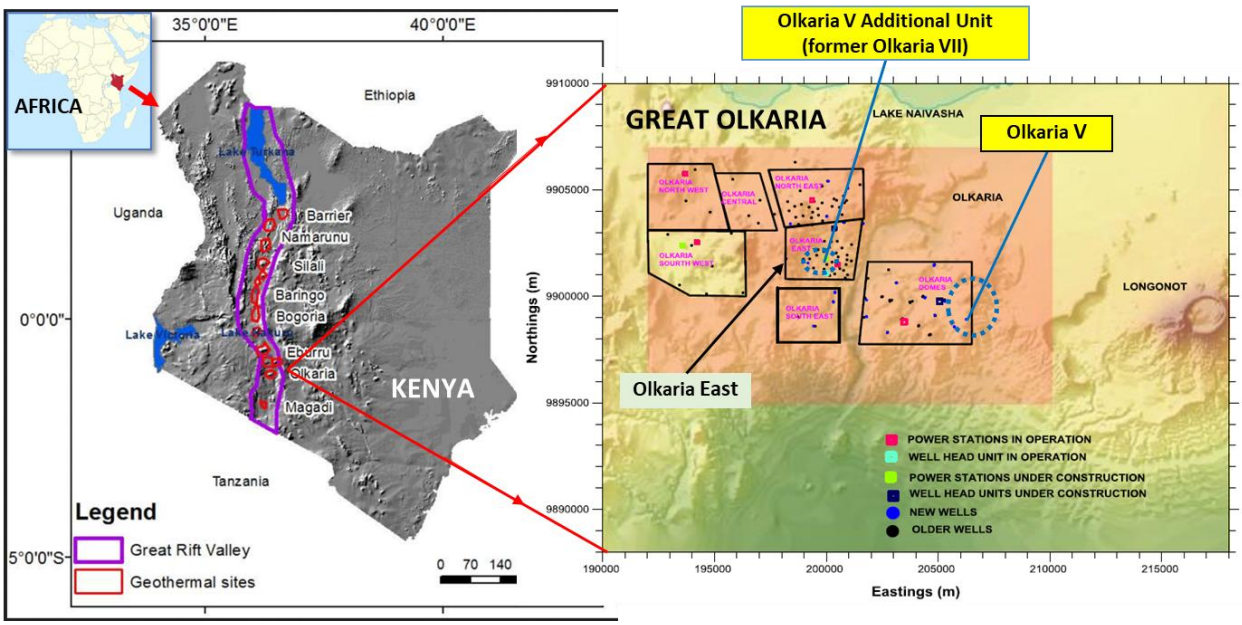
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Revision G

REVISION HISTORY				
Revision	**Date**	**Description / amends**	**Revised by**	**Approved by**
A	26 Feb. 2026	Revised from Draft Final Report	EU	TY
B	28 Nov.2024	Revised as per internal comments	EU	TY
C	14 Feb. 2025	Edits for Draft Final Report	EU	TY
D	18 Aug. 2025	Use OW-48B instead of OW-39 & OW-39B	EU	TY
E	12 Sep. 2025	Added Provisional sums, DB costs and revised Administration Fee	EU	TY
F	3 Oct. 2025	Updated as per JICA comments on Financial-Economical analysis	EU	TY
G	26 Feb. 2026	Revision and update as Final Report	EU	TY

EXECUTIVE SUMMARY

The objective of the Supplementary Study is to evaluate the appropriateness of the geothermal development plan for Olkaria V Additional Unit, as a Project financed by an ODA Yen loan, by examining the existing Feasibility Study Report and other relevant materials.



Olkaria V Additional Unit geothermal development area

The results of the Study can be summarized as follows:

The review of existing Feasibility Study Report confirmed that the project is intended to utilize existing geothermal wells in the Olkaria East production area and includes extensive upstream studies (resource development) as well as downstream studies (construction of power generation facilities). Collection of additional information was attained by inquiring, site reconnaissance and additional analysis of data. The appropriateness of the Olkaria V Additional Unit development plan was examined by integrating all the information collected together with the associated ESIA Report.

From the geothermal resources assessment standpoint, the Study results revealed that the development of 80.3 MW in the Olkaria East production area would be feasible considering that:

- 100% of the necessary amount of steam has been already confirmed available by discharge tests conducted on the existing wells.
- Although three of the wells require the implementation of injection capacity tests, the seven existing reinjection wells assigned to the Project are assumed to sum sufficient reinjection capacity.
- A forecast estimation study showed that sustainability of 80.3 MW of power generation for 25 years is feasible.

The construction costs were updated after the scope of each procurement Lot was clarified by KenGen. . The overall development plan was then examined in regard economic and financial efficiency.

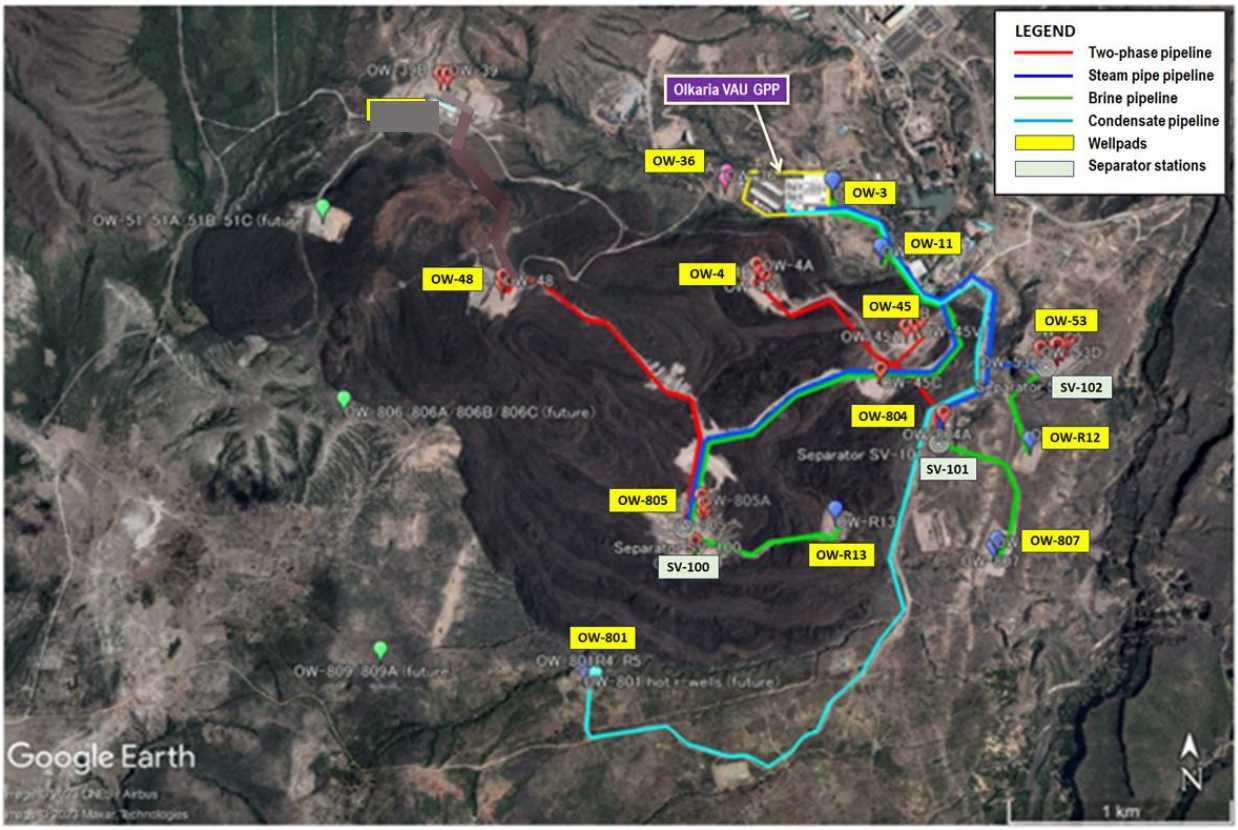
The proposed Site for the Olkaria V Additional Unit power plant, as shown in the figure below, is a gently sloped area (of approximately 380m x 200m) between well pads OW-03 and OW-36. Although the pipeline required to bring steam from the production wells will be relatively long, the selected location shows several advantages such as being on the side of an existing road, volume of required civil works is relatively low if compared with other locations and existing local communities are apart from it.

The capacity and steam consumption of the power plant are as follows:

Steam consumption:	482.5 t/h x 1 unit
Gross output:	80.3 MW x 1 units
Parasitic load:	4.2 MW x 1 units
Net output:	76.14 MW x 1 units

This Study directly assumed the same type of power generation technology for the power plant considered in the KenGen Olkaria-VII Feasibility Study, that is, single-flash cycle with condensing steam turbine, direct contact condenser and wet cooling tower.

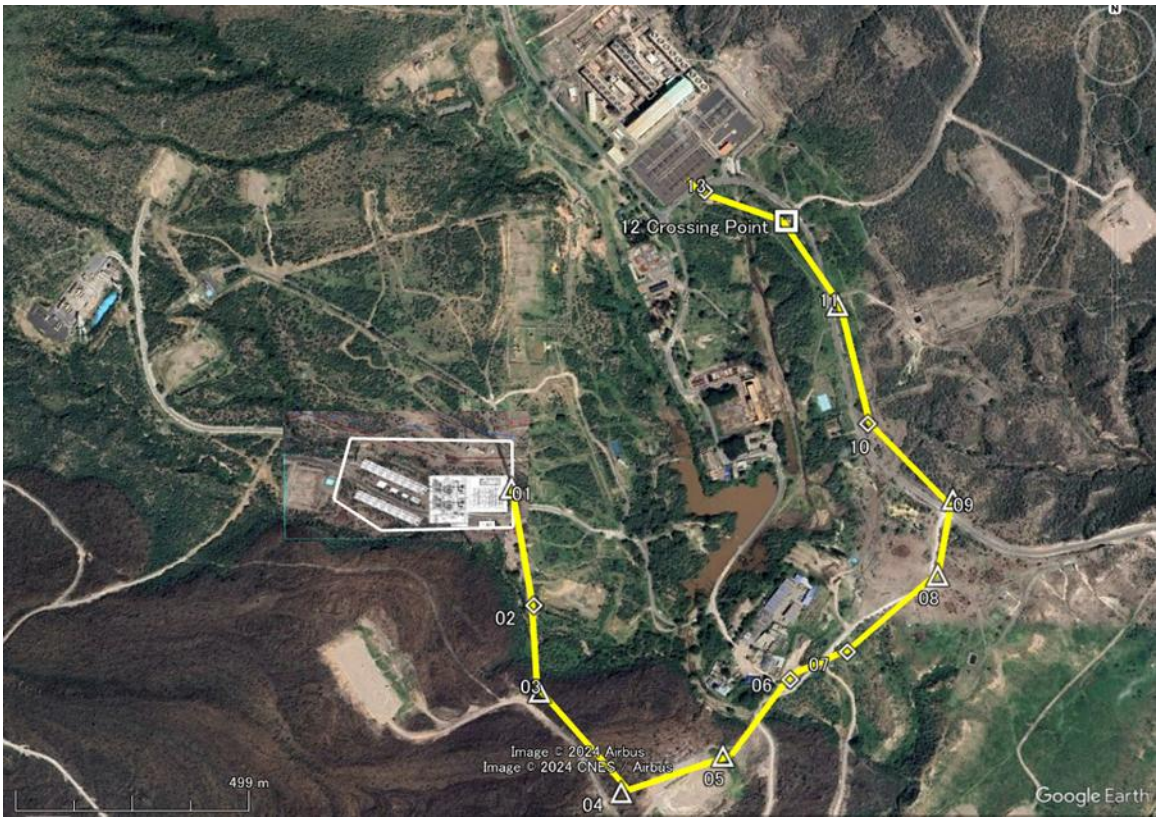
This Report found that the overall pipeline layout planned in the existing Feasibility Study is appropriate except of two wells located within the limits of the National Park, which had to be replaced on grounds of environmental considerations. Also, the design of the steamfield may have to be revised during the SAGS basic design stage upon changes of location of reinjection wells and the results of the highly recommended to be conducted injection capacity tests and geothermal reservoir simulation conducted. The overall revised layout of pipelines and separator stations is shown below.



Location of power plant and pipelines layout in the Olkaria VAU area

A 220 kV double circuit transmission line of 2.5km length will connect the switchyard of the new Olkaria V Additional Unit to the switchyard of the Olkaria IAU GPP Units 4-6.

The Project implementation schedule was prepared assuming that the Loan Agreement (L/A) with JICA will be completed by late March 2026. The Study Team consulted above assumption with KenGen and JICA before compiling it into the Final Report; the scheduling result revealed that the earliest time at which the Olkaria-V Additional Unit plant could be commissioned would be by the end of 2029.



Route of the planned transmission tine (yellow line)

Social-Environmental Considerations

a) Social Considerations

The project is planned on land owned by KenGen and will not require any land acquisition or resettlement. The project area is land transferred to KenGen by the State in 1981 for geothermal development and is unrelated to the land acquired for the construction of the World Bank-funded Olkaria IV power plant.

There are Maasai communities in the surrounding area of the project, which are fully supportive of the project. The nearest Maasai community is more than 2 km away from the project site, and the environmental impact study showed that noise and air pollution levels are well below the levels accepted by environmental standards. The project is not located on a place needing the construction of vehicle access route; therefore, the impact of the project implementation on the communities is expected to be limited. KenGen has established a good relationship with the Maasai through the provision of free water to the community, school buses, and support to women's groups; also. Cattle belonging to the Maasai is allowed to graze on KenGen's land. Given these facts, the negative impact of project implementation on the livelihoods of the Maasai community is considered negligible.

b) Environmental Considerations

Foreseeing the implementation of this Project, on July 2024 KenGen prepared the ESIA Report and submitted it to NEMA for review and approval. NEMA analysed the Report and on May 26th of 2025 formally issued the Environmental License for plant construction. The project construction site and its surroundings are already developed areas with several power plant-related facilities existing already, such as operating geothermal power plants, pipelines, and power transmission towers. The site of the proposed power plant site and its surroundings are made up of bush and grassland with compensatory vegetation; therefore, those areas are not considered to be an important habitat for wildlife.

The Project site is located near the geothermal resources high-use zone of the Hell's Gate National Park and, since the generated power shall be evacuated through the Olkaria-IAU plant, part of the transmission line has been planned to be built along existing roads within the National Park. KenGen has acquired the license for geothermal resource development for the entire Project site, so there are no legal issues regarding development activities within the National Park. Noise impacts during construction are expected but will be temporary.

In addition, KenGen has signed a MoU with the KWS, the Kenyan entity which manages the National Park, and development activities within the park are discussed at regular meetings between the two parties with environmental considerations being addressed based on the mentioned MoU. During an interview with KWS by the Study Team, KWS commented that they would like to cooperate with this Project.

List of Annexed Documents

ANNEX-I

Appendixes in Annex-I

Appendix No.	Description
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Appendix I-2	Comparison with similar projects in Olkaria
Appendix I-3	LCPDP Recommended Power Expansion Plan
Appendix I-4	KenGen Risk Profile and Mitigation Policy

ANNEX-II

Appendixes in Annex-II

Appendix No.	Description
Appendix II-1	Grid connection Stability Study

ANNEX-III

Appendixes in Annex-III

Appendix No.	Description
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Appendix No.	Description
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List of Acronyms and Abbreviations

ABBREVIATION	DESCRIPTION
AfDB	African Development Bank
CAPEX	Capital Expenditure
CBR	California Bering Ratio (a soil support ratio)
COD	Commercial Operation Date
EIB	European Development Bank
EIRR	Economical Internal Rate of Return
DISCO	Private Power Distribution Companies in Kenya
DCRS	Debit Coverage Service Rate
DCP	Dynamic Cone Penetrator (a test measuring soil support)
EPRA	Energy and Petroleum Regulatory Authority
ESIA	Environmental and Social Impact Assessment
FIRR	Financial Internal Rate of Return
FY	Fiscal Year and/or Financial Year (from July to June next year)
GERD	Grand Ethiopian Renaissance Dam (Ethiopia)
GOK	Government of Kenya
GPP	Geothermal Power Plant
GPS	Global Positioning System
GNSS	Global Navigation Satellite Systems (for Topographical survey)
HES	Health, Safety and Environment
HDPE	High-density polyethylene (material for pipes)
H_2S	Hydrogen Sulphide (gas)
ICB	International Competitive Bidding
IDA	International Development Association
KenGen	Kenya Electricity Generating Company PLC
KES	Kenyan Shilling
KETRACO	Kenya Electricity Transmission Company Ltd
KfW	Kreditanstalt für Wiederaufbau -"Credit Institute for Reconstruction" -
KPLC	Kenya Power and Lighting Company
LCCA	Life Cycle Cost Analysis
LCD	Liquid Cristal Display
LCPDP	Least Cost Power Development Plan
LIDAR	Light Detecting and Ranging
LCOE	Lowest Cost of Energy
LNG	Liquid Natural Gas
MoE	Ministry of Energy (formerly Ministry of Energy and Petroleum MoEP)
MW	Mega Watt, power unit equivalent to one-million Watt

MTP	Medium Term Plan (Kenya power supply)
NEMA	National Environment Management Authority
NCG	Non-Condensable Gases
NVP	Net Present Value
OPEX	Operation expenditure
O&M	Operation and Maintenance
ORC	Organic Rankine Cycle
ORMAT	Binary Technology generation Equipment Manufacturer
ORPOWER	IPP Generation Company - Olkaria-III Power Plant-
OSH	Occupational Safety and Health
OW	Olkaria Well
PLC	Public Limited Company
PSS/E	Power System Simulation for Engineering
REREC	Rural Electrification and Renewable Energy Corporation
ROE	Return of Equity
SAGS	Steamfield Above Ground System (fluids gathering/ hauling system)
S.S.	Sub-station or power plant switchyard
T.L.	Transmission Line
West JEC	West Japan Engineering Consultants, Inc.

1. INTRODUCTION

1.1. BACKGROUND

The development of geothermal power generation is becoming increasingly important in Kenya as it represents a stable renewable energy source, undisturbed by weather conditions and credited to emit much less air pollutants and CO_2 than thermal power plants of the same size which, in addition, cause a large burden for the country's finances due fuel importing costs.

According to the Kenyan Energy and Petroleum Regulatory Authority, the power demand in the country is steadily increasing and is expected to peak 2,269MW in 2024 and 5,757MW by 2041. Through Fiscal Year 2022-23 geothermal energy accounted for 45.4% of the total power generated in the country, hydraulic sources 19.3%, wind 16.6%, thermal 10.5% and, solar 3.3%; nevertheless, while ten years ago hydro generation represented roughly 50% of the power generated in the country; dry seasons and repeated droughts have steadily reduced its share.

Due its privileged location in the Great Rift Valley of East Africa, Kenya has been endowed with a large geothermal potential estimated to reach 10,000MWe. Congruently, the "Updated Least Cost Power Development Plan -Study Period 2022-2041", announced by the Kenyan Ministry of Energy and Petroleum, and the GOK's mid-term infrastructure sector plan (Mid Term Plan IV 2023-2027), consider essential the development of the national geothermal resources and assign high priority to power generation projects in the Olkaria area.

The Olkaria V Additional Unit Project is among the geothermal generation ventured deserving preferential attention from the GOK. The foundations of Project have been laid through the conceptual design developed in a feasibility study outsourced by KenGen in 2023 and recently completed under the denomination of "Olkaria-VII Geothermal Plant Feasibility Study".

The abovementioned Olkaria-VII geothermal plant Project has been renamed as Olkaria V Additional Unit on the grounds that the Government of Japan through the Japan International Cooperation Agency -JICA-, has committed to partially fund the Project by sourcing financial resources from a remaining balance of the ODA loan granted at the time of construction of the Olkaria-V geothermal plant, commissioned in 2019 in the Domes Sector of the Greater Olkaria Field.

Seeking to fulfil the Financer's formal conditions and internal procedures for the release of the abovementioned remaining ODA loan portion, JICA has entrusted West JEC, who in turn appointed a group of their personnel (hereinafter "the Study Team"), with the preparation of the present Supplementary Feasibility Study.

1.2. PURPOSE OF THE SUPPLEMENTARY FEASIBILITY STUDY

The purpose of the Supplementary Study for the Olkaria V Geothermal Power Plant Additional Unit is to conduct a close examination, review and improvement as necessary of the "basic plan" for implementing the construction of the Project, intended by KenGen on its role of Executing Agency. The said "basic plan" mainly encompasses the abovementioned Feasibility Study, both from technical and socio-environmental standpoint, the confirmation by the Study Team of the organization and capabilities of the Executing Agency for implementing the Project and, the previsions it may be taking to implement the Project.

Considering the neediness of smooth and prompt construction of the purposed plant, this Supplementary Study involves considerations and advice on the validity of the specifications of the envisioned additional power generation unit accounting for high efficiency equipment.

Namely, the Supplementary Study shall address the following objectives:

a) Confirmation of Project appropriateness based on Kenya's, power demand, supply and trends.

b) A comprehensive review and confirmation of the geothermal resources in the area of study.

c) Review of power plant conceptual design and appropriateness of the proposed equipment.

d) Updating of information for implementing the construction of powerhouse, auxiliary facilities and steamfield aboveground system.

e) Review of Project's overall cost, operation & maintenance costs and financing plans.

f) Propose a structure for Project implementation, make a review of the procurement method and, propose an operation & maintenance system.

g) Make recommendations for the optimization of the ESIA scope as necessary and such to meet the standards and conditions set by the JICA Guidelines for Environmental and Social considerations (issued April 2010) hereinafter referred as the JICA Guidelines.

h) Considerations on Project effect indicators (Project operation /effect indicators, qualitative effects, collection of basic data, calculation of FIRR and EIRR sensitivity analysis)

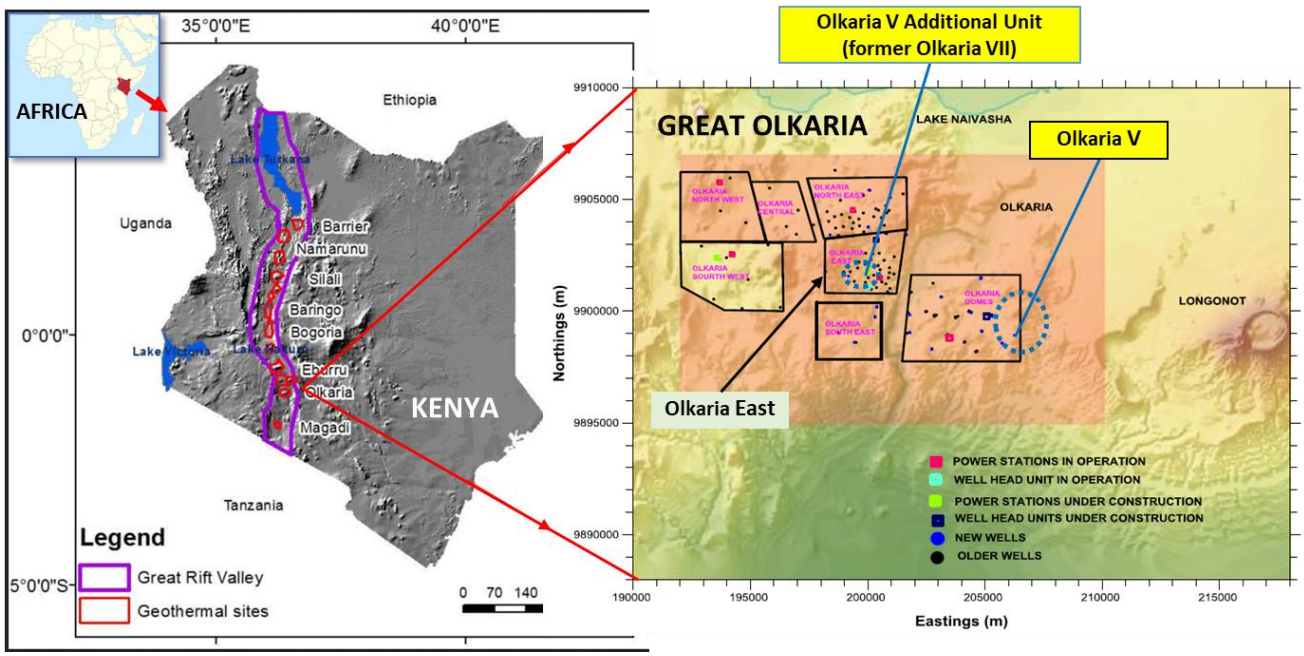
i) Review and confirmation of the financial status of the Executing Agency

1.3. STUDY AREA

The area of study encompassed through the Supplementary Study includes the entire East Production Zone of the Greater Olkaria geothermal field.

The Greater Olkaria geothermal field is located in Nakuru county, central Kenya at the southern portion of the Great Rift Valley and about 120km from Nairobi. There are several other geothermal prospects and fields along the Kenyan portion of the Rift Valley and at several stages of exploration, development and exploitation.

The field covers an area of about 204 km^2, which, for the sake of rationalizing its development, was divided into seven sectors: Olkaria East, Olkaria West, Olkaria Northwest, Olkaria Northeast, Olkaria Central, Olkaria Domes and Olkaria Southwest. Refer to Figure 1.3-1 below.



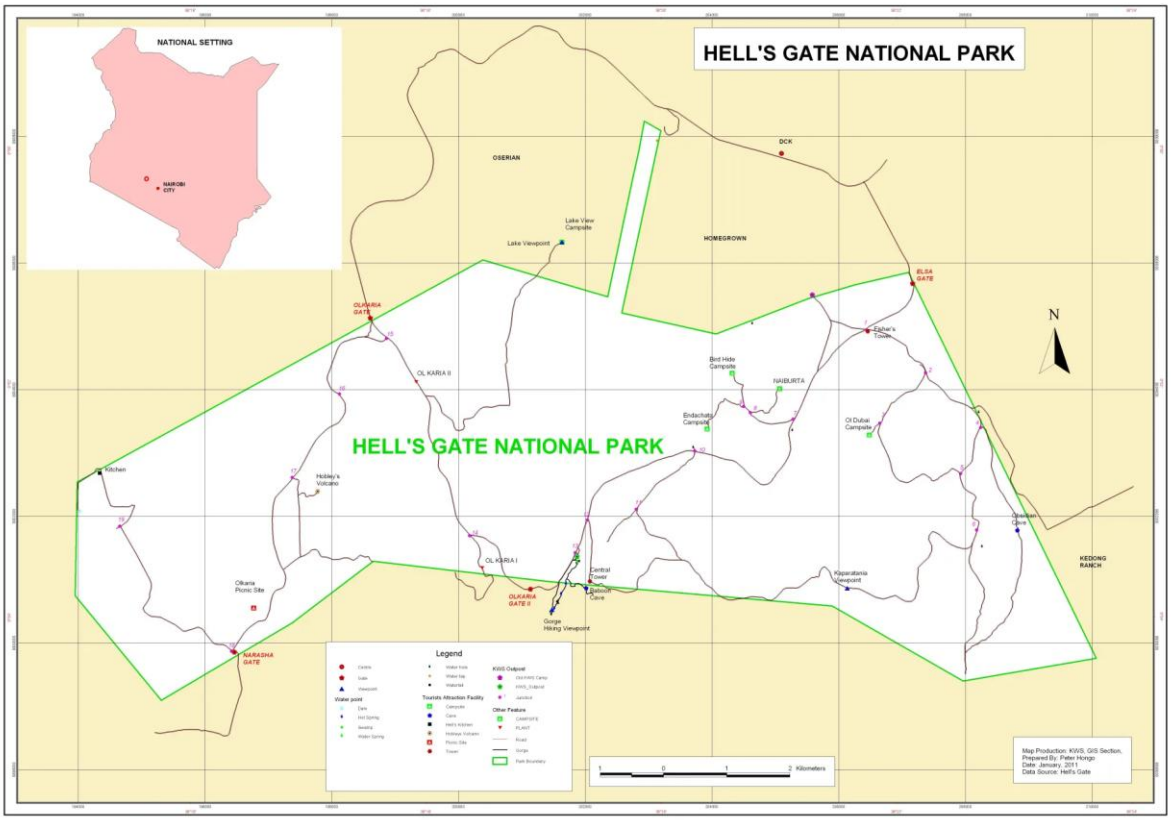
(Source: Study Team, edit assembly from [1], [2])

Figure 1.3-1. Olkaria V Additional Unit geothermal development area

[1] Mary W. Macharia, Moses K. Gachari, et al.; "Low-Cost Geothermal Energy Indicators and Exploration Methods in Kenya". Journal of Geography and Regional Planning, accepted on 21 June 2017. Research Paper.

[2] Irene Ronoh. "Appraising a Geothermal Field using Hydrothermal Alteration Mineralogy: a Case Study of the East of Olkaria Domes Geothermal Field". Proceedings World Geothermal Congress 2015, Melbourne, Australia.

The Hell's Gate National Park (Figure 1.3-2) was established in 1984 and two years after the commissioning of the first unit of the Olkaria-I power plant.



(Source: Study Team from [3])

Figure 1.3-2 The Hell's Gate National Park

1.4. PROJECT EXECUTING AGENCY AND COUNTERPART

The Project Executing Agency is the Kenya Electricity Generating Company PLC – KenGen – through its Design and Construction Unit. KenGen counterpart staff is shown in Table 1.5-1.

KenGen was established in 1954 with the mandate to generate electricity through the development, management and operation of power plants. Since its inception not only made considerable inroads in Kenya's energy sector but also has become the leading electric power generating company in East Africa. With a share of 65% of the Kenyan market and an installed capacity of 1,904MW, comprising hydraulic, thermal, geothermal and wind power plants. KenGen is also the largest energy producer in East Africa.

Starting in the 50's, several years of geothermal exploration and drilling led to the construction and successful commissioning of the first unit of Olkaria-I power plant in 1982. This pioneering effort was followed by the development, construction and commissioning of the Olkaria-II, Olkaria IV, Olkaria IAU 4&5 and Olkaria V and several small-size geothermal generation projects. KenGen has also surpassed Kenyan borders and is currently working at Tulu Moye Geothermal Operations (TMGO) with the Ethiopia Electric Power (EEP) and, L'office Djiboutien de développement de l'energie geothermique (ODDEG), of Djibouti.

[3] The Kenyan Camper. On line article published on March 11, 2016, https:// the kenyan camper. Word press.com /2016/03/11/hells-gate-national-park-kenya/hells-gate-national-park-_2-1/

The current geothermal portfolio of KenGen comprises the ownership and operation of the abovementioned six central geothermal power plants in Olkaria in addition of fifteen modular wellhead plants and one wellhead plant located in Eburru, totalising 799MW of overall installed capacity. Furthermore, including the Olkaria V Additional Unit Project, KenGen is planning to add geothermal generating capacity and surpass 1,000MW of installed capacity within this decade.

1.5. ALLOCATION OF EXPERTS

Table 1.5-1 summarises the tasks assigned to each member of the Supplementary Study Team and the counterpart staff assigned by Executing Agency.

Table 1.5-1. Allocation of Experts

Name	Position	Task	Counterpart personnel KenGen
Takeshi Yamamoto	Team leader, Project development	Project Management	Thaddeus Kwoba
Takeharu Okamoto	Reservoir Engineer	Review of geothermal resource	Gideon Gitonga
Hideki Hatanaka	Reservoir Engineer	Review of geothermal resource	Felix Mwarania
Erwin Urquiola	Geothermal power plant Engineer (Mechanical)	Review of Power Plant & SAGS Implementation plan	Reuben Langat Winnie Apiyo Moses Latina
Taro Nakamura	Geothermal power plant Engineer (Electrical)	Review of Power Plant implementation plan	Andrew Mbaji
Teruaki Matsuo	Power evacuation system expert	Review of Power evacuation system plan and PSSE study	
Hidenobu Ishimaru	Civil Engineer	Review of Civil works Plan and implementation	Rehema Ocharo
Takeshi Yamashita	Economist	Economic and Financial evaluation	Beatrice Musyoka with Faiza Mohamed for financial statements
Jumpei Kubota	Environmental Expert (Environment)	Review of ESIA report. Support services related to JICA's Environmental and social Consideration Advisory Committee	Rose Mathenge Cornelius Ndetei
Shatei Iri	Environmental Expert (Social)		Simon Kisotu with Gad Msewe for land property issues

1.6. SCHEDULE OF SURVEYS IN KENYA

Two field surveys in Kenya were implemented by the members of the Study Team. The first field survey was implemented in the last week of July 2024 and the second through the last week of August 2025.

The activities developed through the surveys are summarised in Table 1.6-1 and included collection of data, interviews to stakeholders and presentations in front of the Executing Agency relevant to the power plant construction project and associated Social-Environmental considerations, reporting of Project partial advance and conclusions.

Table 1.6-1. Participants and schedule of the First and Second field Survey to Kenya

Name:		Yamamoto Takeshi	Urquiola Erwin F.	Kubota, Jumpei	Iri, Shatei
date	**day**	**FIRST MISSION -YEAR 2024**			
July 22	Mon	9:00 meeting at KenGen Head Office, 11:30 meeting at JICA Kenya Office			
		Move to Naivasha			
July 23	Tue	Meeting at Olkaria Geothermal Plaza			
		Field survey: Water intake, pumping station, water tanks, wells OW39, OW48, OW805, power plant former prospective Sites #6 and #7			
July 24	Wed	Data collection at Olkaria Geothermal Plaza		Interviewing to KWS Senior assistant director Hell's Gate National Park	
				Interviewing to WRA – Regional Manager, Naivasha	
July 25	Thu	Field survey (Olkaria II)		Interviewing to Maasai Community Leaders at Olkaria Geothermal Plaza	
		Field survey (OW801 well pad, Maasai cultural centre, Olkaria V #1&2 area, Transmission Line route, brine pond with fence, Olkaria geothermal spa)			
July 26	Fri	Wrap-up meeting at Olkaria Geothermal Plaza			
		Move to Nairobi			
date	**day**	**SECOND MISSION - YEAR 2025 -**			
August 25	Mon	Project DFR presentation at KenGen Head Office			
August 26	Tue	Move to Naivasha			
August 27	Wed	Olkaria field survey: survey at Olkaria-V power plant and OW-57 drilling pad Inspection of environmentally delicate spots			
August 28	Thu	Olkaria field survey: confirmation of pending matters with KWS Meeting at Ol-Maiyama village; ESIA-related meeting with KenGen,			
August 29	Fri	Olkaria field survey: Inspection of environmentally delicate spots Mission wrap-up meetings in Nairobi with JICA and KenGen attendance			

1.7. LIST OF COLLECTED INFORMATION

The information collected by the Study Team is indicated as general lists found in the Annex-III of the Supplementary Study Report.

2. METHODOLOGY

2.1. ENERGY DEMAND STATUS AND PROJECT NEEDINESS CONFIRMATION BASED ON THE KENYAN LCPDP

Considering that almost one year has elapsed since the evaluation of power generation and demand in Kenya were formulated within the Olkaria VII Geothermal Power project Feasibility Study Report (hereinafter referred to as the Olkaria VII F/S Report) and, for the sake of confirming Project necessity, it was desirable to update the abovementioned evaluation.

The Study Team implemented such update mainly based on the latest available Kenyan Least Cost Power Development Plan (LCPDP); however, contributing reference material published by EPRA, KPCL KETRACO was also incorporated whenever was necessary.

2.2. REVIEW OF GEOTHERMAL RESOURCES IN OLKARIA

At the time KenGen engineers were requested to share information on the latest conceptual and numerical models related to geothermal resource assessment and long-term prediction simulations, the Study Team confirmed that the ones updated by the consultant (MANNVIT) in 2017 are the latest. . It was also confirmed that there is not a conceptual model or a numerical model reflecting the development plan for Olkaria-V additional unit. Therefore, by checking the Olkaria VII F/S Report compiled for KenGen in 2024, we will evaluate the potential of geothermal resources related to the Olkaria V additional unit. The evaluation details are listed below in sub-Section 2.2.1.

2.2.1. Evaluation of the characteristics of the geothermal reservoir

KenGen's Feasibility Study Report of Olkaria-VII project was reviewed in terms of the quality of data, the validity of analytical methods and the interpretation of analysis results to determine the reservoir characteristics. Any unclear and/or unreasonable point relevant with data quality, the analytical methods and/or the interpretation of analysis results were clarified with KenGen. If any further improvement is required in the analysis and interpretation of the Feasibility Study Report, it will be described in the Report with the proposed method of revision and improvement.

2.2.2. Evaluation of the forecast of steam production and power output

For geothermal resource assessment, the mass flow rate of production wells and the potential power output shall be estimated during certain period based on development scenarios (Figure 2.2-1).

The result of estimation is variable and depends on how the reservoir characteristics were determined. Therefore, the review of the Feasibility Study Report and later discussion with KenGen will be important for assessing the result of estimation. The assessment covered for the following.

- The estimated mass flow rate for 25 years of operation with the wells planned to be utilized for Olkaria VII area.
- The proper and reasonably considered optimization of the utilization and allocation of both existing wells and planned make up wells within the Olkaria VII area.
- The sustainability of the geothermal resource development for the additional power generation unit of Olkaria V.

2.3. CONCEPTUAL DESIGN CONFIRMATION BASED ON THE CHARACTERISTICS OF THE GEOTHERMAL RESERVOIR

All geothermal power plants in Olkaria operated by KenGen, including the existing units of Olkaria-V plant, utilise the single-flash cycle with condensing turbine technology. Through the development of this Project, the Study Team confirmed that detailed considerations were given at the time of comparing with the alternative power generation technologies proposed in the Olkaria VII Feasibility Study Report. Likewise, the selection of steam conditions and of turbine type were found appropriate. In addition, the layout of the power plant was confirmed to have been duly conducted taking into account technical, meteorological, economic, environmental and social constraints.

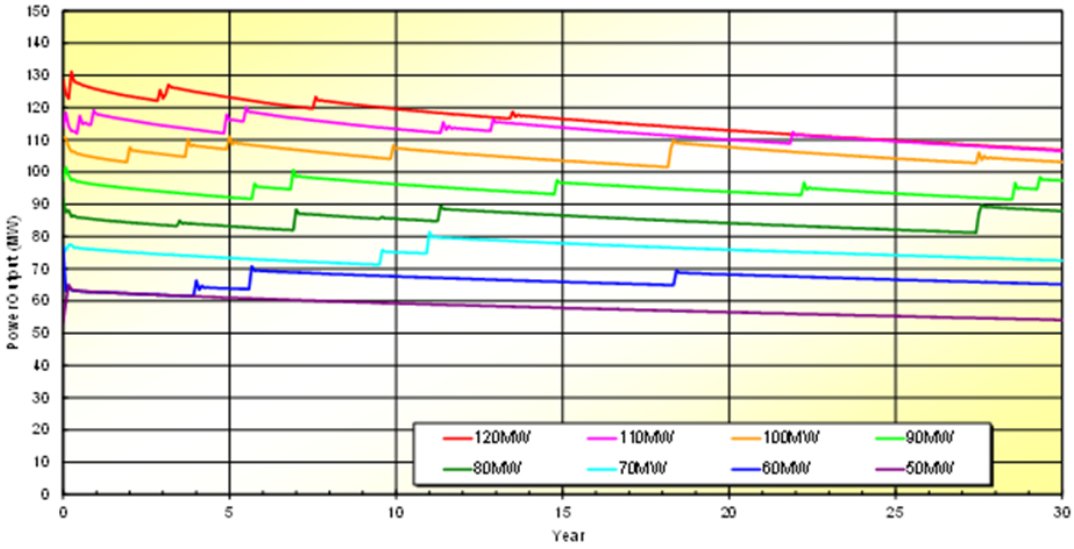


Figure 2.2-1 Schematic image of forecasting estimation

The determination of power output was confirmed by comparing the heat-mass balance calculation with a tuned model based on an existing power plant of the same power output as the plant of the Feasibility Study. The Study Team also confirmed and considered options for a scaled-down Project which the Government of Japan could alternatively finance instead.

Regarding the conceptual design for the Steamfield Aboveground System (SAGS), this based on the location and characteristics of existing production and reinjection wells drilled by KenGen, the Study Team evaluated and adjusted the appropriateness of the piping system configuration (process flow diagram), location of separator stations, pipeline routes and pipelines sizing, as are described in the existing Feasibility Study for this Project. Confirmation also included a new-drilled condensate reinjection well, as well as topographical characteristics and eventual interference with existing facilities.

2.4. REVIEW OF PLAN AND DESIGN OF THE POWER EVACUATION SYSTEM

2.4.1. Transmission Line route

Several Transmission lines crisscross the Olkaria area: double-circuit 220kV transmission lines have been constructed from Olkaria-IAU and Olkaria-IV bound to Suswa substation and a double-circuit 220kV transmission line is in operation from Olkaria IAU to Olkaria-II power plant, and, there is also a single-circuit 132kV transmission line running from Olkaria-I to Naivasha substation via Olkaria-IAU. The Study Team, in addition of confirming that there will be no interference with these existing transmission lines, also confirmed the validity of the route of the planned transmission line this Project taking into consideration the route enters areas designated as of the National Park.

2.4.2. System Analysis and System Stability Analysis

(1) Impact of the new Plant on the power grid

The Kenyan Grid Code requires “the ability to operate continuously under conditions of voltage fluctuations due to the transmission system”.

The operation of the new Plant and the planned evacuation system through Olkaria-IAU substation were confirmed not to eventually impact the stability of the nearby transmission grid in regard phase, voltage fluctuations and others arising from the operation of the Project, nor be impacted from the system of nearby power generation units, as presented in the dedicated Grid Connection and Stability Study, Annex-II of this Report.

Besides new power plants scheduled to be commissioned in Olkaria, the Study Team considered KenGen's new planned geothermal wellhead power generation facilities in the area and the future development of the power transmission system, all according the LCPDP 2024-2043 and the Kenya Vision Plan 2030.

(2) Impact from the power grid on the new Plant

Since Kenyan Grid Code requires "the ability to operate continuously under conditions of voltage fluctuations due to the transmission system", the voltage response and frequency response analysis implemented in the Olkaria-VII F.S. Report were reviewed through PSS/E to ensure the power plant will meet the Kenyan grid code requirements when connected to the grid. The Study Team investigated: a) Olkaria IAU-Naivasha 132kV line failure, b) Olkaria IAU, Olkaria II and Olkaria-IV to Suswa 220kV line failure, c) Suswa-Nairobi line failure, and d) whether the power plant meets the grid code requirements in case any unit of the Olkaria IAU or Olkaria IV power plant is disconnected from the grid. A detailed purposed grid connection stability study was implemented and has been attached to this Report as Annex II.

While power evacuation from the Paka-I 100MW GPP (Baringo-Silali region) may be delayed until 2027 or later, the proposed use of the Loosuk-Baringo-Lessos 400kV transmission line will have only slight impact on the stability study results of the Baringo-Lesos-Olkaria-Suswa line.

In regard the three GPP projects with COD scheduled on FY2027 (that is, including in addition the Olkaria VAU and the Olkaria II expansion GPP projects) even if the COD of these three GPPs is delayed, should the commercial operation date COD of each plant be achieved in the order listed in the LCPDP [1] the impact on the grid stability analysis results would be small, if any. However, should the completion of the Olkaria II expansion project be further delayed and the plant is commissioned after the Olkaria VAU, there might be some impact from the grid on the Olkaria VAU performance.
Review of environmental and social considerations

2.5. REVIEW OF ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

The JICA Guidelines classifies this Project as of Category A since it belongs to the geothermal power generation sector. In this Study, the Project's Environmental and Social Impact Assessment (ESIA) Report submitted by KenGen to NEMA in July 2024 has been reviewed in view of the JICA Guidelines for Environmental and Social Considerations; several other surveys based on the same Guidelines were conducted as necessary. Likewise, the potential neediness of residents' relocation and the status of land acquisition due the implementation of to this Project were surveyed and confirmed. In addition, the potential neediness of an Indigenous Peoples Plan (IPP) with reference to the KenGen's Feasibility Study was evaluated also.

The implementation of the Study required to subcontract a local Kenyan Consultant to ensure smooth communication through the survey and effective execution of the collection of data related to environmental and social considerations.

2.6. ESTIMATION OF THE PROJECT COST

The Study Team conducted the review of each item depicted within the budged formulated for the Olkaria-VII Feasibility Study. The cost of each item accrued within the CAPEX budget was found to be fully justified. Especial considerations were given to the re-evaluation of drilling, SAGS and power plant costs, all of them encompassing a large portion of the CAPEX.

Moreover, aiming to contribute to the certainty of the financial-economic evaluation, the Study Team focused also on the evaluation of plant OPEX and its budget; O&M cost data and other referential parameters sourced from KenGen. In addition, costs relevant with the mitigation of social-environmental impacts during plant and subsequent monitoring were reviewed and updated as necessary.

[1] The LCPDP 2024-2043, page 91, lists CODs of geothermal power plant in the Baringo-Silali and Olkaria areas through Fiscal Year 2027 in the following order: first Paka I (100MW, Baringo-Silali area); second, Olkaria II extension (also known as Olkaria VI, 140MW); and third, Olkaria VAU (also known as Olkaria VII, 80MW)

2.7. REVIEW OF PROJECT IMPLEMENTATION SCHEDULE

The revision of the Project implementation schedule was based on the timetable found within the Olkaria-VII Feasibility Study. The Study Team welcomed the participation of assigned counterpart personnel and other personnel from KenGen who contributed to the revision with their large experience dealing with EPC contractors.

2.8. CONFIRMATION OF PROJECT ORGANIZATIONAL STRUCTURE FOR OPERATION AND MAINTENANCE

The Study Team conducted a survey into the Executing Agency structure and its Project implementation arm with the purpose of overviewing its organizational structure, procedures management and control capabilities, power plant operations, economic-financial and environmental matters.

2.9. FINANCIAL - ECONOMIC EVALUATION

The Study Team implemented the Financial Economical re-evaluation and confirmation of the Project accounting on the following tasks:

2.9.1. Review of the financial status of KenGen

- Review of financial statements of KenGen achieved during the past 5 years, including profit and loss statements, balance sheets and cash flow statements.
- Review and analysis of the financial status will focus on historical changes relevant with i) profitability, ii) operating efficiency, iii) solvency and iv) liquidity.

2.9.2. Economic Analysis of the Project

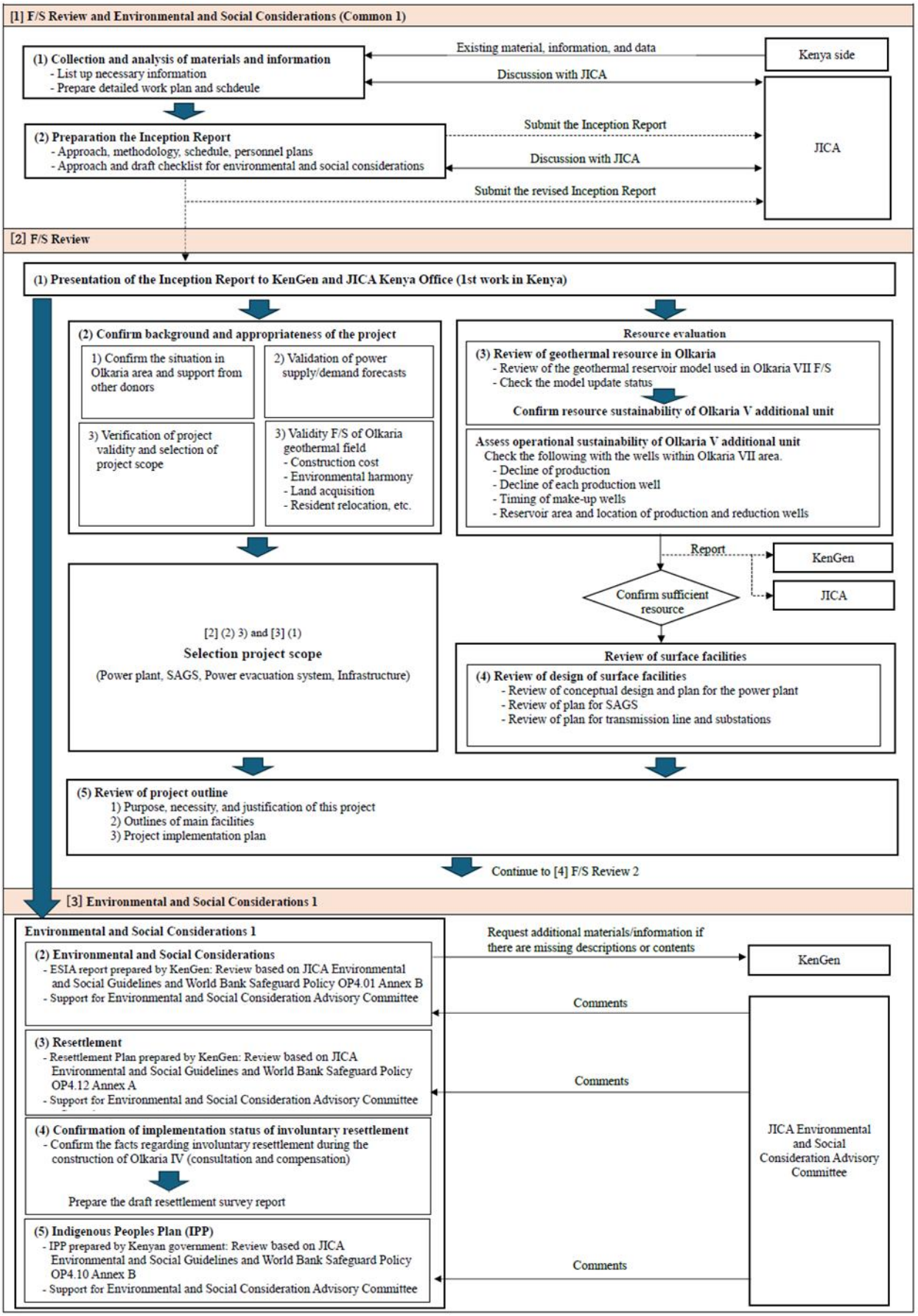
- Estimate the annual disbursement schedule of capital costs and O&M costs of the Project in economic price.
- Identify economic benefits of the Project, which shall consist of i) avoided cost of an alternative base-load power plant, and ii) CO_2 reduction effect, which will be estimated based on a Certified Emission Reduction (CER) and its trading value.
- Calculate EIRR of the Project to verify the Project's economic feasibility from the standpoint of the national economy.
- The Sensitivity analysis was executed to understand the robustness of economic feasibility as against the adverse changes in various key assumptions (capital cost, make-up well requirement, construction period, plant load factor, CO_2 trading value, etc.).

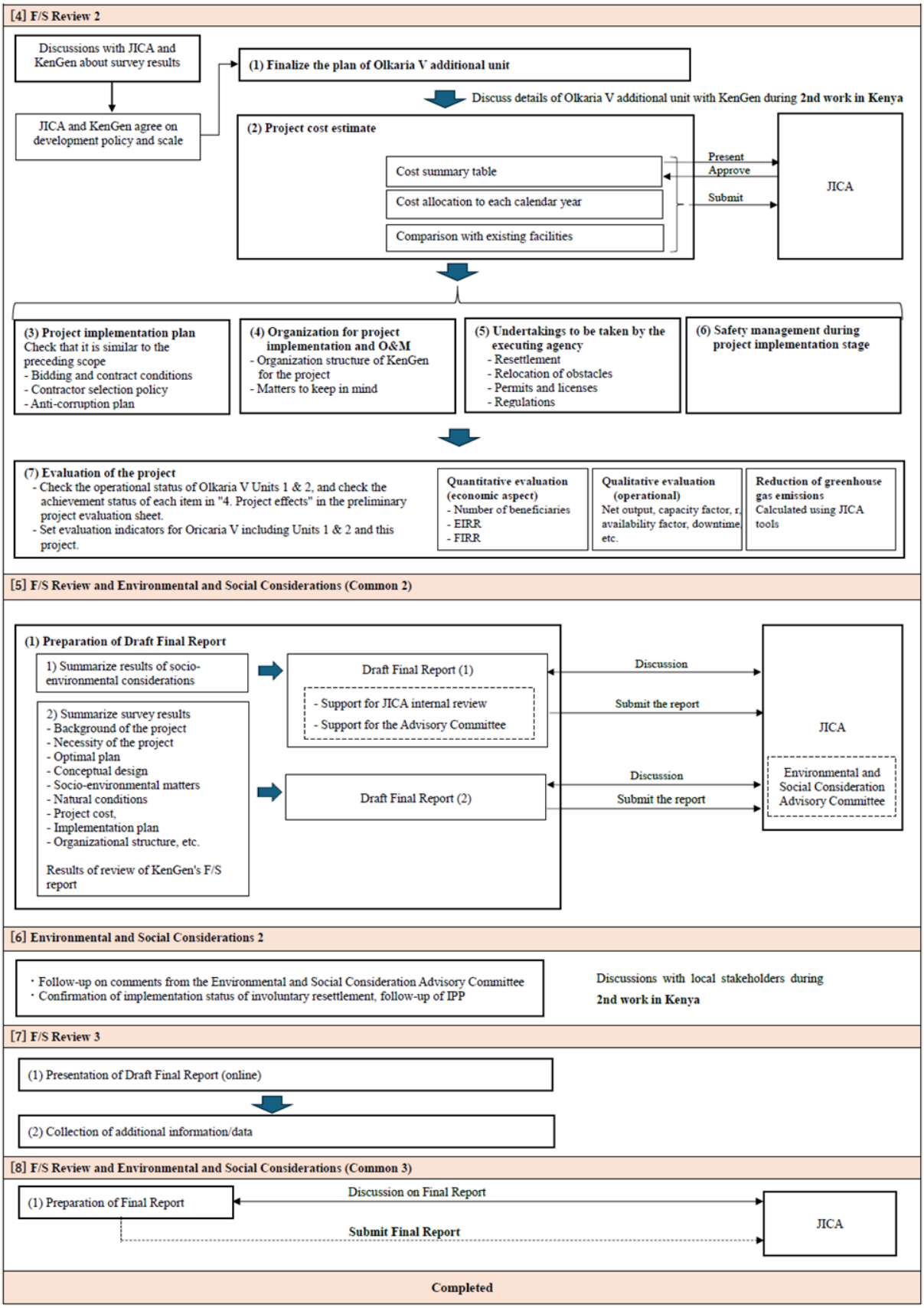
2.9.3. Financial Analysis of the Project:

- Formulate a financial cash flow of the Project based on the Project cost estimate, and revenue from sale of electricity as well as taxes applicable for geothermal projects in the country.
- Confirm the financial feasibility of the Project by comparing FIRR and the weighted average cost of capital (WACC)
- Calculate the Levelized Cost of Electricity (LCoE) of the new unit and then identify its price competitiveness among the other power plants/ generating units.
- Calculate the debt service coverage ratio (DSCR) and the loan-file coverage ratio (LLCR) of the Project to clarify sufficiency of operating revenue for loan repayment.
- Execute Sensitivity analysis in order to understand the robustness of financial feasibility as against adverse changes in various key assumptions (capital cost, make-up wells requirements, O&M cost, construction period, plant load factor, loan terms, etc.).

2.10. STUDY IMPLEMENTATION FLOW

Figure 2.10-1, next page, shows the workflow implemented for developing this Supplementary Study.


[1] F/S Review and Environmental and Social Considerations (Common 1)
(1) Collection and analysis of materials and information
- List up necessary information
- Prepare detailed work plan and schdeule
Existing material, information, and data
Discussion with JICA
Kenya side
(2) Preparation the Inception Report
- Approach, methodology, schedule, personnel plans
- Approach and draft checklist for environmental and social considerations
Submit the Inception Report
Discussion with JICA
Submit the revised Inception Report
JICA
[2] F/S Review
(1) Presentation of the Inception Report to KenGen and JICA Kenya Office (1st work in Kenya)
(2) Confirm background and appropriateness of the project
1) Confirm the situation in Olkaria area and support from other donors
2) Validation of power supply/demand forecasts
3) Verification of project validity and selection of project scope
3) Validity F/S of Olkaria geothermal field
- Construction cost
- Environmental harmony
- Land acquisition
- Resident relocation, etc.
Resource evaluation
(3) Review of geothermal resource in Olkaria
- Review of the geothermal reservoir model used in Olkaria VII F/S
- Check the model update status
Confirm resource sustainability of Olkaria V additional unit
Assess operational sustainability of Olkaria V additional unit
Check the following with the wells within Olkaria VII area.
- Decline of production
- Decline of each production well
- Timing of make-up wells
- Reservoir area and location of production and reduction wells
Report
KenGen
JICA
Confirm sufficient resource
[2] (2) 3) and [3] (1)
Selection project scope
(Power plant, SAGS, Power evacuation system, Infrastructure)
Review of surface facilities
(4) Review of design of surface facilities
- Review of conceptual design and plan for the power plant
- Review of plan for SAGS
- Review of plan for transmission line and substations
(5) Review of project outline
1) Purpose, necessity, and justification of this project
2) Outlines of main facilities
3) Project implementation plan
Continue to [4] F/S Review 2
[3] Environmental and Social Considerations 1
Environmental and Social Considerations 1
(2) Environmental and Social Considerations
- ESIA report prepared by KenGen: Review based on JICA Environmental and Social Guidelines and World Bank Safeguard Policy OP4.01 Annex B
- Support for Environmental and Social Consideration Advisory Committee
(3) Resettlement
- Resettlement Plan prepared by KenGen: Review based on JICA Environmental and Social Guidelines and World Bank Safeguard Policy OP4.12 Annex A
- Support for Environmental and Social Consideration Advisory Committee
(4) Confirmation of implementation status of involuntary resettlement
- Confirm the facts regarding involuntary resettlement during the construction of Olkaria IV (consultation and compensation)
Prepare the draft resettlement survey report
(5) Indigenous Peoples Plan (IPP)
- IPP prepared by Kenyan government: Review based on JICA Environmental and Social Guidelines and World Bank Safeguard Policy OP4.10 Annex B
- Support for Environmental and Social Consideration Advisory Committee
Request additional materials/information if there are missing descriptions or contents
KenGen
Comments
Comments
Comments
JICA Environmental and Social Consideration Advisory Committee



(Source: Study Team)

Figure 2.10-1 Workflow for the development of the Supplementary Feasibility Study

2.11. TIMETABLE

The Supplementary Feasibility Study is being developed in accordance the timetable of Table 2.10-1.

Table -2.10-1 Project Schedule

TASK			Assginment of Experts										Study Implementation Schedule																		
			Team Leader	Reservoir engineer	Reservoir evaluation	Plant (mechanical)	Plant (electrical)	Power evacuation	Civil engineer	Economist	Environmental expert	Social expert	Year 2024							Year 2025											Year 2026	
													Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Site visit	1)	Feasibility Study	●			●								▼													▼					
	2)	Socio-Environmental considerations									●	●		▼													▼					
F/S Review and Environmental and Social Considerations (Common 1)	1)	Collection and analysis of related materials and information	●	●	●	●	●	●	●	●	●	●																				
	2)	Preparation of Inception Report and presentation to JICA	●	●	●	●	●	●	●	●	●	●																				
F/S Review 1	1)	Presentation of Inception Report to KenGen and JICA Kenya Office	●			●					●	●																				
	2)	Confirm background and appropriateness of the Project	●			●																										
	3)	Review of geothermal resources		●	●																											
	4)	Review of design of surface facilities	●			●																										
	5)	Review of Project outline	●		●	●	●	●	●																							
	6)	Review of the Project schedule	●			●		●																								
Environmental and Social Considerations 1	1)	Selection of Project scope									●	●																				
	2)	Environmental and Social Considerations									●	●																				
	3)	Resettlement										●																				
	4)	Confirm implementation status of involuntary resettlement										●																				
	5)	Indigenous Peoples Plan (IPP)										●																				
F/S Review 2	1)	Finalize implementation plan for Olkaria V additional unit	●			●		●																								
	2)	Project cost estimate	●			●				●																						
	3)	Project implementation plan				●			●																							
	4)	Organization for Project implementation and O&M	●			●																										
	5)	Undertakings by the executing Agency	●			●			●																							
	6)	Safety management during Project implementation stage				●																										
	7)	Evaluation of the Project	●							●	●																					
F/S Review and Environmental and Social Considerations (Common 2)	1)	Prepare Draft Final Report and present to JICA	●	●	●	●	●	●	●	●	●	●																				
	2)	Support for JICA internal review									●	●																				
Environmental and Social Considerations 2	1)	Follow up on comments made by JICA Environmental and Social Consideration Advisory Committee	●								●	●																				
F/S Review 3	1)	Presentation of Draft Final Report	●	●	●	●	●	●	●	●																						
	2)	Collection of additional information/data as necessary	●	●	●	●	●	●	●	●	●	●																				
F/S Review and Environmental and Social Considerations (Common 3)	1)	Preparation of Final Report	●	●	●	●	●	●	●	●	●	●																				
Deliverables	1)	Inception Report	●	●	●	●	●	●	●	●	●	●			▲																	
	2)	Draft final Report (1) of Environmental and Social considerations	●								●	●					▲															
	3)	Draft Final report (2)	●	●	●	●	●	●	●	●											▲											
	4)	Final Report (Pre-release version)	●	●	●	●	●	●	●	●																						▲
	5)	Final Report for Environmental and Social considerations	●								●	●																				▲
	6)	Final Report	●	●	●	●	●	●	●	●	●	●																				▲

Draft Final Report Draft Final Report

(Source: Study Team)

3. RESULTS OF THE SUPPLEMENTARY STUDY

3.1. REVIEW OF ELECTRIC DEMAND AND POWER DEVELOPMENT PLAN IN KENYA

The Study Team conducted a review of the situation of the power sector in Kenya to confirm the neediness of implementing the construction of the Olkaria VAU geothermal power plant.

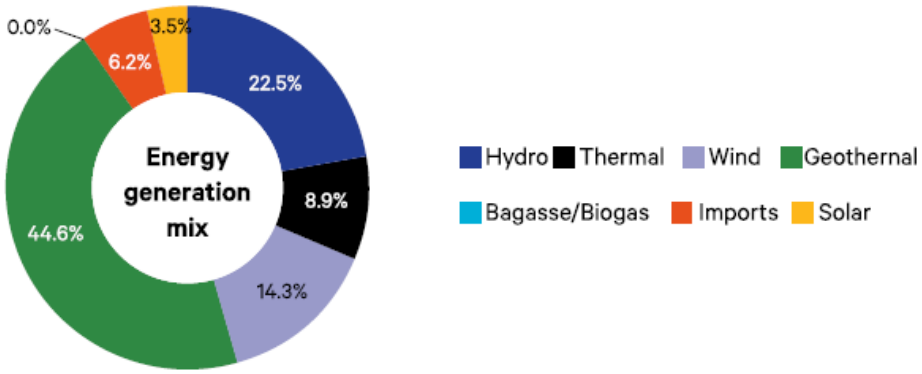
The KenGen's Feasibility Study Report describes the organization of the power sector and the status of power generation and demand in the country as recent as fiscal year 2022-2023; the Report concluded that a new generation plant in Olkaria is necessary for facing a potential supply deficit in the near future. Therefore, and given the dynamism and fast progress of the Kenyan power sector, it is desirable to conduct an update of the relevant section of the abovementioned Report.

3.1.1. Power Sector Situation

Implemented by the GOK since 2008, the Kenya Vision 2030 Plan identifies energy as one of the infrastructure-enablers for the transformation of Kenya into "a newly-industrialising, middle-income country providing a high quality of life to all its citizens in a clean and secure environment". Access to competitively priced, reliable, quality, safe and sustainable energy is essential for achievement of the objectives of year 2030.

In line with the Vision 2030 Plan, renewable energy sources have been prioritized and are increasingly dominating the generation mix of the country currently generating close to 85% of the consumed electricity. Moreover, the GOK has set a target of to achieve 100% of its electrical energy generation from renewable resources by 2030. On the other hand, the portion corresponding to thermal generation has steadily declined from more than 30% in FY 2013/2014 to less than 10% in FY 2023/2024.

Figure 3.1-1 shows the composition of the energy mix in the country as per December 2023. Geothermal sourced energy holds the prime position contributing with 44.6% of the overall energy generated followed by hydro-generated energy with 22.5%.



(Source: EPRA Report FY 2023-2024)

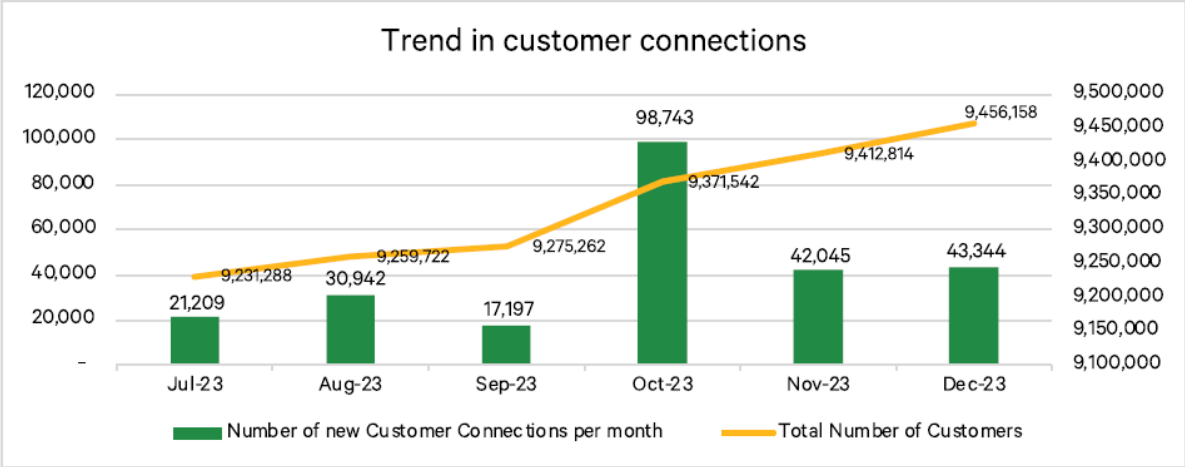
Figure 3.1-1. Kenyan energy mix composition as per December 2023

However, currently, Kenya's endogenous power generation is not enough to satisfy its internal demand; therefore, in addition of an existing energy exchange contract with the Uganda Electricity Transmission Company Ltd. (UETCL), power is also imported from the Ethiopian Electricity Power Company (EEP) under a PPA. Imported power from Uganda and Ethiopia in the period Jan-Dec of 2023 totalized 917.8GWh or 290% growth if compared to the 316GWh imported in the same period of 2022 [1], [2].

In addition, the 508km 400kV transmission line between Kenya and Tanzania, commissioned in December 2024, allows Kenya to import up to 17,520GWh per year from Tanzania.**[1]** Kenya National Bureau of Statistics, KNBS. 2023 Statistical Abstract, page 284. Publicly available.

[2] Xinhua net. On-line press article published at www.xinhuanet.com, Africa news, English, on February 19, 2024.

On the demand side, several power-demanding flag-projects envisioned in the Vision 2030 Plan are yet to be implemented; however, power consumption in the country is growing fast and boosted by the increment of power connections for new customers. As per the end of December 2023, the total number of customer connections reached near 9.45 million following a large increase of more than 0.41 million through 2023, of which 0.25 million were made in the last six months alone, as shown in Figure 3.1-2.



(Source: EPRA Report FY 2023-2024, first half)

Figure 3.1-2. Number and trend of customer connections through the second half of 2023

By customer's category, in the July-December 2023 period, large commercial and industrial customers were responsible of 52.0% (2,71GWh) of the total national energy consumption while customers of the domestic category utilized 30%. Further details are shown in Table 3.1-1.

Although consumption per household is low if compared with Nairobi, at present, 75% of the country's rural regions have electricity connections and the REREC is targeting to attain 100% power connection in rural Kenya by 2030 [3].

Table 3.1-1 Energy consumption and categories in the first half of FY2023-24

Customer category	Energy consumption (GWh)	Percentage
Industrial	2,706.62	51.99%
Domestic	1,599.33	30.72%
Electric Mobility	0.32	0.01%
Small commercial (SMEs)	843.04	16.19%
Street lighting	56.48	1.08%
Total	**5,205.79**	**100.00%**

(Source: EPRA Report, FY 2023-2024 first half)

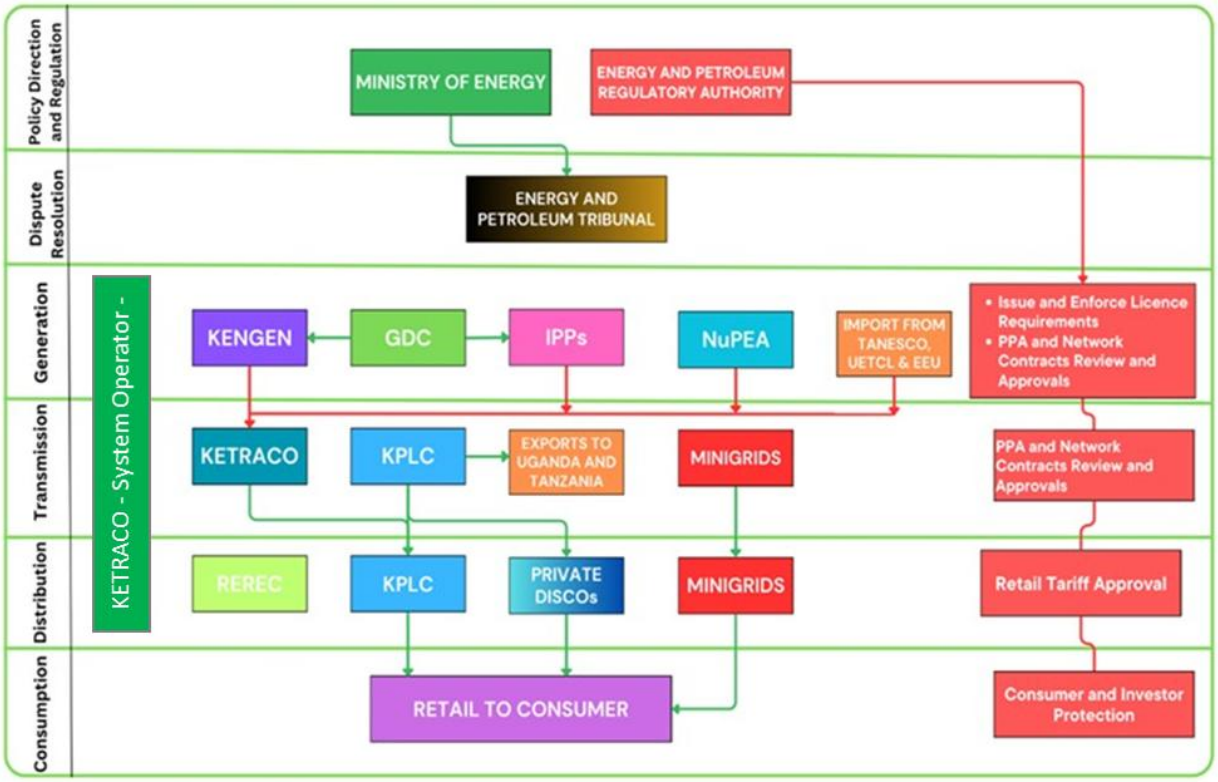
3.1.2. Power Sector Institutional Structure

The Ministry of Energy (MoE) manages the energy sector in Kenya and has the mandate to generate policies designed to create and enable the right environment for the efficient operation and growth of the sector. The MoE sets the strategic direction for the growth of the sector and provides a long-term vision for all sector players. The MoE has five Directorates namely, Petroleum Energy, Geo-Exploration, Renewable Energy, Electrical Power, General Administration and Support Services to facilitate delivery of its mandate. The Energy Act 2019 details the scope of MoE mandates.

[3] ESI-Africa. "Rural energy drive in Kenya as REREC aims 100% electricity access". On-line press article published at https://www.esi-africa.com on July 9, 2024.

A group of sectorial institutions acting under the MoE comprises the bulk of the institutional structure of the Kenyan Energy Sector. These include the Energy and Petroleum Regulatory Authority (EPRA), Kenya Pipeline Company (KPC), Kenya Electricity Generating Company (KenGen), Kenya Power and Lighting Company, the Rural Electrification Authority (REREC), Kenya Electricity Transmission Company (KETRACO), Geothermal Development Company (GDC), Nuclear Power and Energy Agency (NuPEA), National Oil Corporation of Kenya (NOCK), and, Kenya Petroleum Refineries Limited. Private sector actors (IPPs, Private DISCOs, and Mini-Grids) and energy service users/customers complete the institutional structure [4].

Figure 3.1-3 shows the institutional organization structure of the Kenyan Energy Sector and depicts the position of the sectorial entities sorted by area of operation and function, say, distribution, transmission, generation, etc. The most left column lists the applicable main regulatory attributes held by the MoE.



(Source: Study Team edited from LCPDP 2022-2041)

Figure 3.1-3 Institutional structure, functions and organization of the Kenyan energy sector

3.1.3. Current Status of Power Facilities

By the end of December 2023, the installed capacity of renewable energy sources amounted 2,776.3MW, constituting 75.2% of Kenya's total installed capacity. The installed capacity figure includes 943.7MW sourced from geothermal facilities, that is, near 30% of the country's interconnected generation capacity; of those, 799MW (about ~85%) were under KenGen geothermal generation operations.

However, through the second half of 2023 curtailment of geothermal energy reached 71.8% of the total curtailed energy. Curtailment involves reducing the power output of a producer which in Kenya typically occurs between 00:00hrs – 04:30hrs, when demand is at its lowest.

[4] Ministry of Energy MoE home page https://www.kpc.co.ke/MoE/

3.1.4. Electricity Supply and Demand

The total installed generation capacity expanded by 58.5% or 1,363MW in the last seven years, from 2,327 MW in 2016 to 3,689.5MW in 2023 inclusive of off-grid capacity. The effective interconnected capacity increased from 2,236MW to 3,051.7MW over the same period, as per the capacity figures in Table 3.1-2 below showing the installed capacity per generation technology each relevant with its connection status.

KenGen is the largest electricity generator in the country accounting for 1,904MW or 62.24% of the effective generation capacity. Independent Power Producers (IPPs) constituted 1,107.6MW (36.3%) and, Off-grid generation, under the governmental Rural Electrification Programme (REP) and implemented by the REREC, accounted for 40.1MW or about 1%.

The peak power demand increased from 1,636MW in July 2016 to 2,170MW in 2023, translating to an average annual growth of 4.2%, as per December 2023.

Table 3.1-2 Installed capacity as per the end of December 2023

Technology	Interconnected Capacity (MW)		Captive Capacity (MW)	Off- grid Capacity	Total Installed Capacity	% Total Installed
	Installed	Effective				
Hydro	839.3	810.4	33.0	0.1	872.4	25.00%
Geothermal	940.0	841.1	3.7		943.7	27.04%
Thermal	572.8	562.4	21.3	35.6	629.7	18.05%
Wind	435.5	425.5	-	0.6	436.1	12.50%
Solar	210.3	210.3	196.2	3.9	410.4	11.76%
Bioenergy	2.0	2.0	111.8	-	113.8	3.26%
Imports	200.0	200.0	-	-	200.0	-
WHRC	-	-	83.5	-	83.5	2.39%
Total	**3, 199.9**	**3,051.7**	**449.5**	**40.1**	**3,689.5**	**100.00%**

(Source: EPRA Report FY 2023-2024)

Geothermal generation, as well, is the leading technology utilized for harnessing and turning into useful power the renewable energy resources of the country. In the six last months of 2023 (first half of FY 2023), geothermal power generation was responsible of generating 44.6% of the electricity in the country, nearly doubling the quantity of energy generated from hydraulic sources. Refer to Table 3.1-3 below showing the generated energy by technology.

Table 3.1-3 Generated energy by technology. July-December 2023

Technology	Energy generated (GWh)	
Hydro	1,534.01	22.5%
Thermal	606.09	8.9%
Wind	972.82	14.3%
Geothermal	3,032.03	44.6%
Biomass	0.21	0.0%
Imports	419.13	6.2%
Solar	240.99	3.5%
	6,805.28	**100%**

(Source: EPRA Report FY 2023-2024)

In regard power imports, Kenya maintains power exchange agreements with Uganda since 1964 and is one of its power imports sources and export market too. Provisions are made in the LCPDP for completing the construction of the 400kV, 132km double-circuit line from Lessos to-Tororo, Uganda, with a total capacity of 1,400MVA, which will allow to increase power trade between the countries.

In addition, the 1,068km long, 500kV HVDC bipolar line with a capacity of 2,000MW running from Wolayta-Sodo (Ethiopia) to Suswa (Kenya) commissioned in 2021, enables a 25-year PPA agreement allowing Kenya Power to take up a maximum 200MW dams hydropower from the GERD in the first three years, additional 200MW in 2026 and, another 200MW for export to Tanzania. Through the PPA, Kenya is buying Ethiopian power at 6.50 USD cents/ kWh, which is significantly lower than the tariffs charged by local Kenyan IPPs (around 10.0 USD cents/kWh).

In order to stabilize power supply stretched due historic droughts, Kenya officially started importing 200MW from Ethiopia as early as January 2022. However, since Ethiopia is grappling with a sizeable electrification deficit, resulting in widespread power outages and weak access to electricity in rural areas, in addition of political instability, Kenyan authorities are reported concerned about the stability of the supply and which could affect their own power supply security [5].

3.1.5. Electricity Retail Tariff

The overall electricity tariff in Kenya has two components: the "Basic electricity Tariff", a fixed component, periodically revised, that covers the cost of producing electricity, and a variable component which includes pass-through costs as well government taxes and levies. Chargers are applied to four customer categories, each with sub-categories based on energy consumption limits, as per Table 3.1-4.

In March 2023, the Authority approved the "Base electricity tariff" corresponding to the tariff control period spanning from FY2023 to FY2026. The "Base electricity tariff" consists of various factors, including the cost of generating, transmitting and distributing electricity, energy losses occurring during transmission as well as profit margins for the utility company.

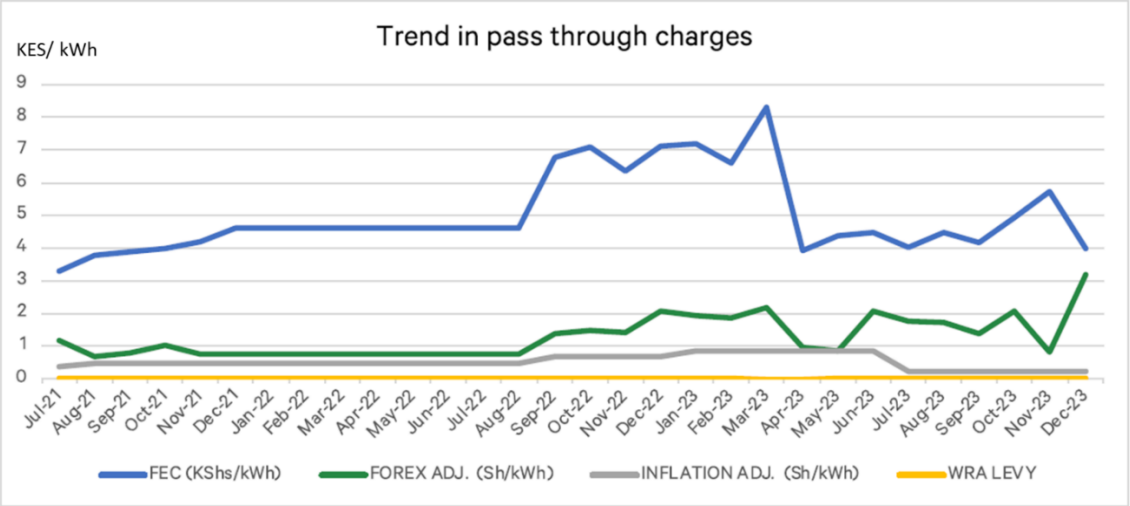
Table 3.1-4 Base tariff for FY 2023/2024

Customer category	Voltage at connection	Energy Limit (kWh/month)	Base Tariff (Ksh.)	Demand Charge (Kshs.)
Domestic	240 Volts/415 Volts	0-30	12.24	0
		31-100	16.58	0
		>100	20.58	0
Small Commercial	240 Volts/415 Volts	0-30	12.24	0
		31-100	16.36	0
		>100	20.00	0
Electric Mobility	240 Volts/415 Volts	200-15,000	16.00	0
Commercial/Industrial	415 Volts	>15,000	14.50	1,100
	11,000 Volts	No Limit	13.08	700
	33,000 Volts	No Limit	12.52	370
	66,000 Volts	No Limit	12.26	300
	132,000 Volts	No Limit	11.98	300
Street Lighting	240Volts/450 volts	No Limit	9.24	0

(Source: EPRA Report FY 2023-2024)

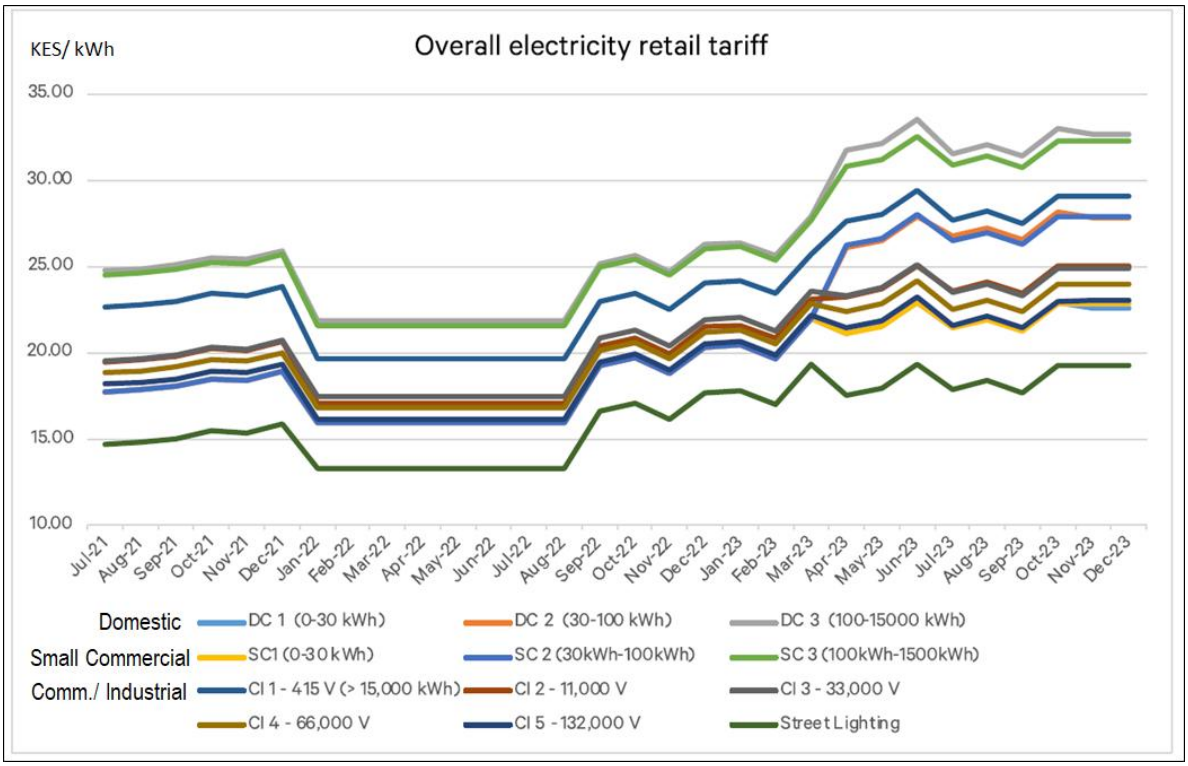
Pass-through charges are monthly revised by EPRA and the implemented to cover additional expenses incurred by electricity generation plants. These comprise Fuel Energy Costs (FEC), Water Resource Management Authority (WRMA) levy, and Foreign Exchange Rates Fluctuations Adjustment (FERFA) and on inflation and taxes adjustments. Refer to Figure 3.1-4, pass-through charges, and Figure 3.1-5, the overall retail tariff.

[5] The East African. "Ethiopia units top Kenya's record electricity imports". Online press article published at https://www.esi-africa.com on April 6, 2023.



(Source: EPRA Report FY 2023-2024)

Figure 3.1-4 Trend in pass-through charges between July 2023 and December 2023



(Source: EPRA Report FY 2023-2024)

Figure 3.1-5 Trend in the overall electricity retail tariff between July 2021 and December 2023

Commercial and Industrial consumers can benefit with 50% discount on the energy charge rates during the off-peak hours. This is known as the Time-off-Use tariff (ToU tariff) and is applicable from 22:00hrs to 06:00hrs during weekdays, 14:00 to 00:00 on Saturdays and through the whole day during Sundays and Public holydays.

3.1.6. Load Demand Forecast

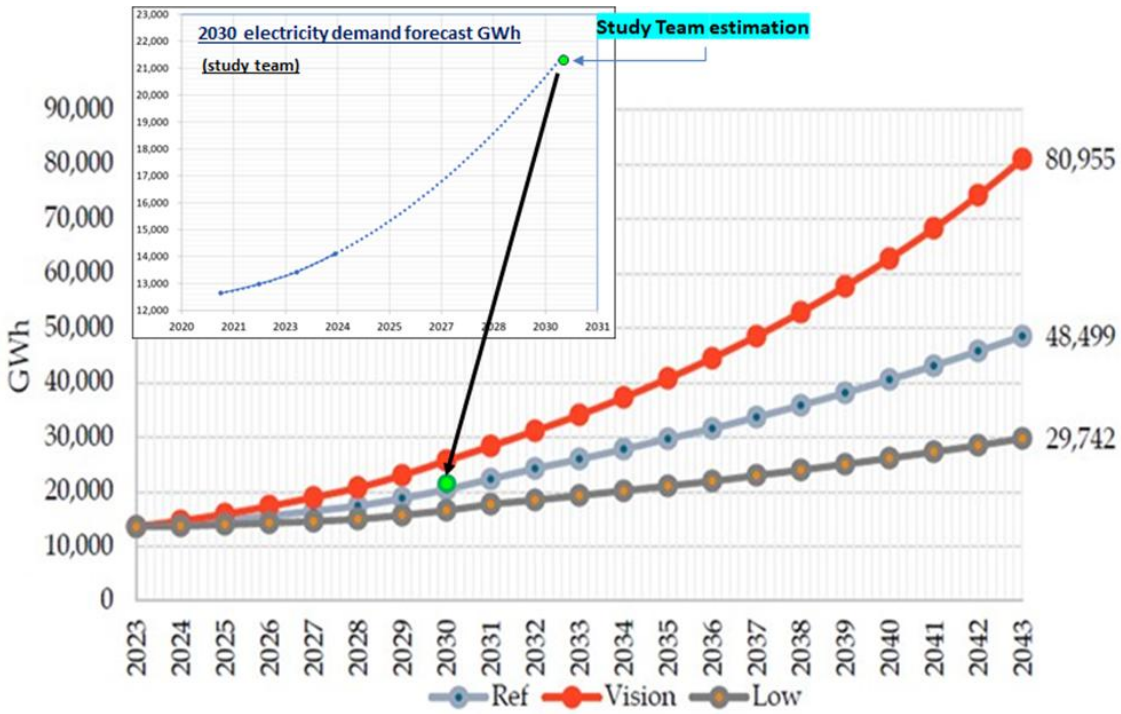
The contents of this sub-section have been limited to a revision of the forecasted installed capacity and the load demand included in the recently released LCPDP 2024-2043.

Several market players have scheduled the commissioning of new power generation facilities for the following years, as well, some other facilities in current operation are scheduled to be decommissioned or, in some cases, re-powered. The above-mentioned facilities are listed in the LCDPD recently released by the MoE covering the period of years 2024 to 2043 [6].

In connection power demand forecast, the LCPDP considers factors influencing demand growth such as demographics, GDP growth and the Vision 2030 Flagship projects; in addition, future demand drivers such E-cooking, E-mobility and green hydrogen (ammonia) are considered also. The results are presented accrued into three scenarios: a "Reference" scenario, the "Vision 2030" scenario, and a "Low" scenario. Accordingly, the peak demand will increase from 2,170 MW in 2023 to 3,361MW, 4,230 MW and 2,606 MW in 2030 for the Reference, Vision and Low scenarios respectively; and, to 8,152MW, 13,495 MW, and 4,996 MW respectively in 2043 for the same scenarios. Figure 3.1-6 illustrates the forecasted power demand under the three scenarios.

In regard the purchased energy, it is expected to grow at an annual average rate of 6.6% from 13,627GWh in 2023 to 48,499GWh in 2043 under the Reference scenario, and at a rate of 9.3% to 80,955GWh in 2043 in the Vision scenario. In the Low scenario, the energy purchased is expected to grow at an average rate of only 4.0%, that is, to 29,742GWh over the same period.

Based on data from the last four years [7], the Study Team has estimated that electricity demand in the short term could be only slightly higher than the approximately 21,000GWh forecasted by the Reference scenario, that is, reaching 21,400 or 21,500GWh by year 2030.



(Source: LCPDP 2024-2043)

Figure 3.1-6 Forecasted power demand for three development scenarios

[6] Ministry of Energy, MoE. LCPDP 2024-2043. Pages 87-114, Table 6-2.

[7] Energy & Petroleum Statistics Reports, FYs 2021,2022, 2023 and 2024. Energy & Petroleum Regulatory Authority, EPRA.

3.1.7. Power Generation Expansion Plan

The 2024-2043 LCPDP details the expansion planning for installed power generation; this is described along transmission and distribution projects and in accordance the three demand development scenarios described in subsection 3.1.6 above. The expansion plan includes a large a number of generation projects sourced from renewable resources and, in general, the country seems performing in line with the medium-term clean energy goal set for 2030 and, the long-term net-zero aspiration set for 2050. Renewable sources, nuclear and imports will provide the required electricity generation mix by 2043, already representing a full transition to clean energy.

In the short term, year 2028, the total interconnected effective capacity would be 4,654MW of which 3,257MW would be firm capacity. By 2043, the total interconnected effective capacity is projected to reach 12,800MW, 9,182MW of which as firm capacity. At that time, geothermal installed capacity is expected to top 3,680MW [8], for far becoming the biggest contributor of the total electricity generation mix with a share of 47.6%. There will be also significant contributions from nuclear generation, Battery Energy Storage Systems (BESS) and pumped hydro storage for grid stability by 2043 and all diesel and gasoil power plants are expected to be decommissioned by 2035 [9] and, by 2043, renewable sources, nuclear generation and imports which, with significant contributions from battery energy storage systems (BESS) and pumped hydro storage for grid stability, will provide the required electricity generation mix, already representing a full transition to clean energy.

Nevertheless, a review of the LCPDP document brings into consideration facts that may have significant impact in the accuracy of the power supply forecasts made and in the short and middle term country's stability in regard power supply. Among others, the LCPDP sets FY 2027 for the commissioning of the 100MW Baringo-Silali-geothermal project, the 140MW Olkaria-II Extension project and this Olkaria-VAU project, schedule that the Study Team perceives as highly challenging or not realistic.

Therefore, the Study Team has prepared an upgraded evaluation of the power supply-demand balance in the country for the short and middle terms which is compared with the LCPDP recommended supply expansion and demand forecast. The result for the commissioning of firm capacity of geothermal power generation, backbone of the last updated LCPDP, is summarised in Table 3.1-5 below with assumed time terms pointed out in Table 3.1-6 and illustrated in Figure 3.1-7.

Table 3.1-5 LCPD middle term supply-demand balance and Study Team evaluation

mark	LCPDP 2024-2043						Study Team		
	Peak load	Peak load + reserve Ⓐ	reserve margin	Installed capacity	Firm capacity	supply-demand gap	Installed capacity	Firm capacity Ⓑ	supply/demand gap Ⓐ-Ⓑ
FY	MW	MW	% peak load	MW	MW	MW	MW	MW	MW
2024	2,327	2,643	14%	3,110	2,395	-248	3,082	2,367	-276
2025	2,446	2,774	13%	3,308	2,525	-229	3,249	2,466	-308
2026	2,575	2,916	13%	3,952	2,911	-8	3,893	2,850	-66
2027	2,716	3,071	13%	4,401	3,245	130	4,120	2,995	-76
2028	2,871	3,241	13%	4,654	3,257	16	4,554	3,157	-84
2029	3,093	3,486	13%	5,079	3,550	64	4,979	3,351	-135
2030	3,361	3,780	12%	5,492	3,797	16	5,392	3,697	-83

(LCPDP 2024-2043/ Study Team)

[8] Ministry of Energy, MoE. LCPDP 2024-2043. Page 84, Figure 6-2.

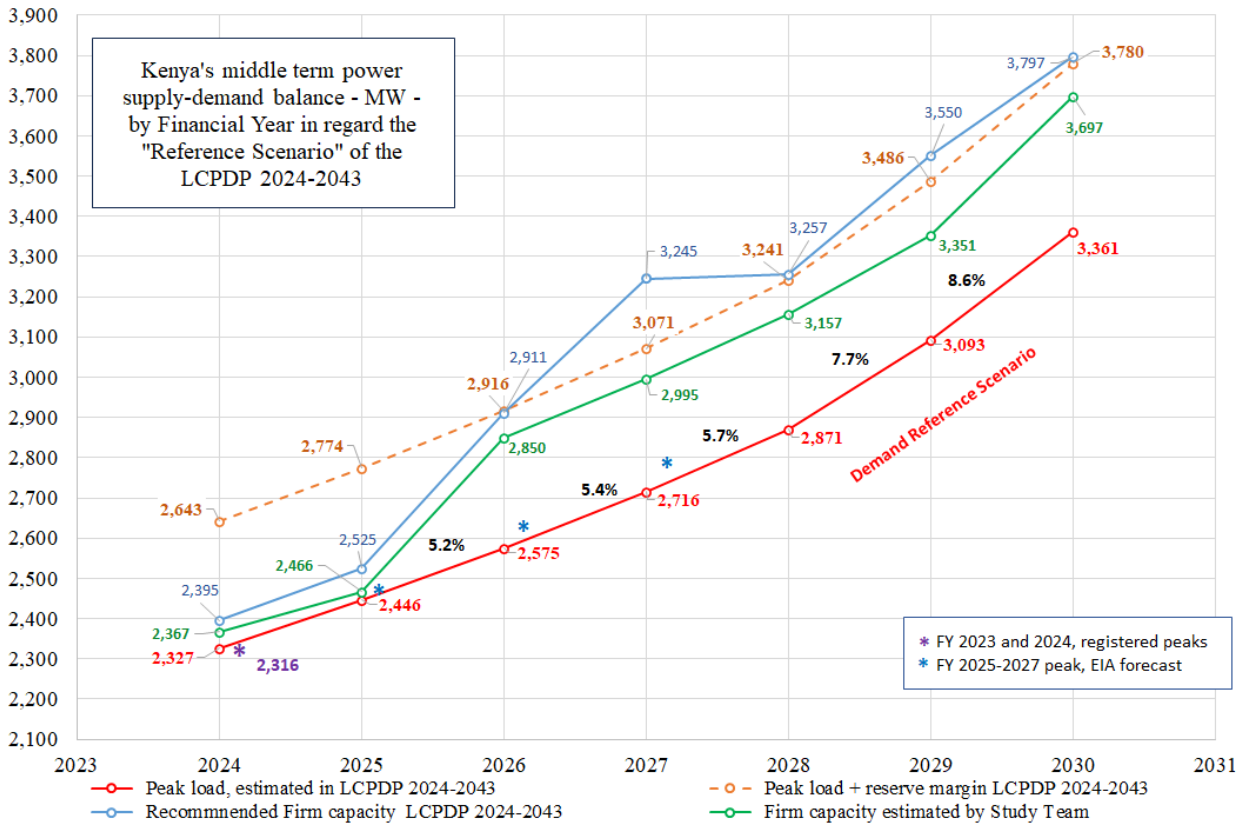
[9] Ministry of Energy, MoE. LCPDP 2024-2043. Page 84.

Table 3.1-6 LCDP-recommended and estimated COD for upcoming geothermal projects

2025	2026	2027	2028	2029	2030
LCPDP recommended COD - FY -					
Menengai Quantum	Olkaria-IV uprate	Paka-1	-	Baringo-Silali-1	-
Menengai OrPower	Olk-IAU-4 & 5 uprate	Olkaria-II Ext. 2x70	-	Menengai-III	-
WellHeads leasing	Olkaria-I rehab.	Olkaria-VAU	-		-
35 + 35 + 58.6	20 + 20 + 21+21+21	100 + 140 + 80.3	-	100+100	-
Study Team COD factual assumption - FY -					
Quantum Or Power	as scheduled	Olkaria-II Ext. 1x70	Olkaria-II Ext. 1x70	Paka-1	Menengai-III
		Wellheads leasing	0		(Silali)
35 + 35 + 0	20 + 20 + 3x21	0 + 70 + 58.6 + 0	70 + 80.3	100 + 0 + 0	0 + 100

(source: Study Team)

The evaluation foresees that the first Unit of Olkaria-II-Extension could only be commissioned in FY 2027 and the second Unit in FY 2028, COD of the Olkaria VAU would be on FY 2028, COD of Baringo Paka-I and Silali-I plants would be delayed to FY 2029 and 2030 respectively. The Study Team assumes that Menengai III project could be commissioned only by FY 2031, two years later than it is recommended in the LCPDP. At the time, power import would surpass 1,000MW.



(Source: Study Team)

Figure 3.1-7 Analysis of the middle term supply-demand balance scenario

In regard the "estimated assumptions" adopted above, although the Feasibility Study of Olkaria-II Extension was completed, the Study Team was not granted with updated information on its scheduled COD nor on the status of loan/s procurement, that on grounds it shall yet remain as KenGen's confidential information yet. However, based on the usual time the realisation of a geothermal project of the intended size does require, in favourable circumstances its first power generation unit could be commissioned by FY 2027 and the second by FY 2028.

The construction schedule of the Olkaria VAU Project, considered in sub-section 3.4.8., suggests that the COD will be achievable by the beginning of the second half of FY 2029 at the earliest, should a Loan Agreement for this Project is completed by March 2026. However, other pertaining formal documents may need yet to be completed, further delaying the commissioning of the plant.

In regard the Baringo-Silali and Paka projects, at the time of writing this Study GDC, the in-charge entity, is yet in the process of developing the geothermal resource and implementing its evaluation. Some publicly available information found on the internet highlights the huge potential of the fields and apparent sufficiency for the intended generation capacity; however, little is known yet in regard the development of a steamfield or in regard potential IPP developers interested in the construction of power generation facilities.

Considering the time that it takes to implement necessary feasibility studies, PPA negotiations (usually lengthy and difficult which in the geothermal industry) and plant construction, the Study Team assumes to be uncertain to see the Baringo-Silali area generating power before FY 2029.

3.1.8. Background Validity of the Project

The summary of power supply-demand balance for the middle term, Reference Scenario, Table 6-1 on page 85 of the LCPDP 2024-2043 and which was re-evaluated by the Study Team resulting in Figure 3.1-7, shows that the projected firm power supply capacity, including imports, is only enough to cover the forecasted demand but with less than 15% of reserve margin. Since there is a likely scenario on which the local supply would not grow as forecasted making the reserve margin further reduced, the no-implementation of the Olkaria VAU Project would only exacerbate the power supply deficit and force growing imports of energy.

The above-described projected middle-term deficit of installed power generation capacity in the country does not only support the validity of the Olkaria VAU Project but, also, strongly urges its implementation. Nowadays, a large portion of the national middle-term power generation capacity depends on timely developing the geothermal generation projects listed in the latest LCPDP; geothermal generation is the backbone of the middle term electricity supply plan and swift actions are required to meet the tight development schedules.

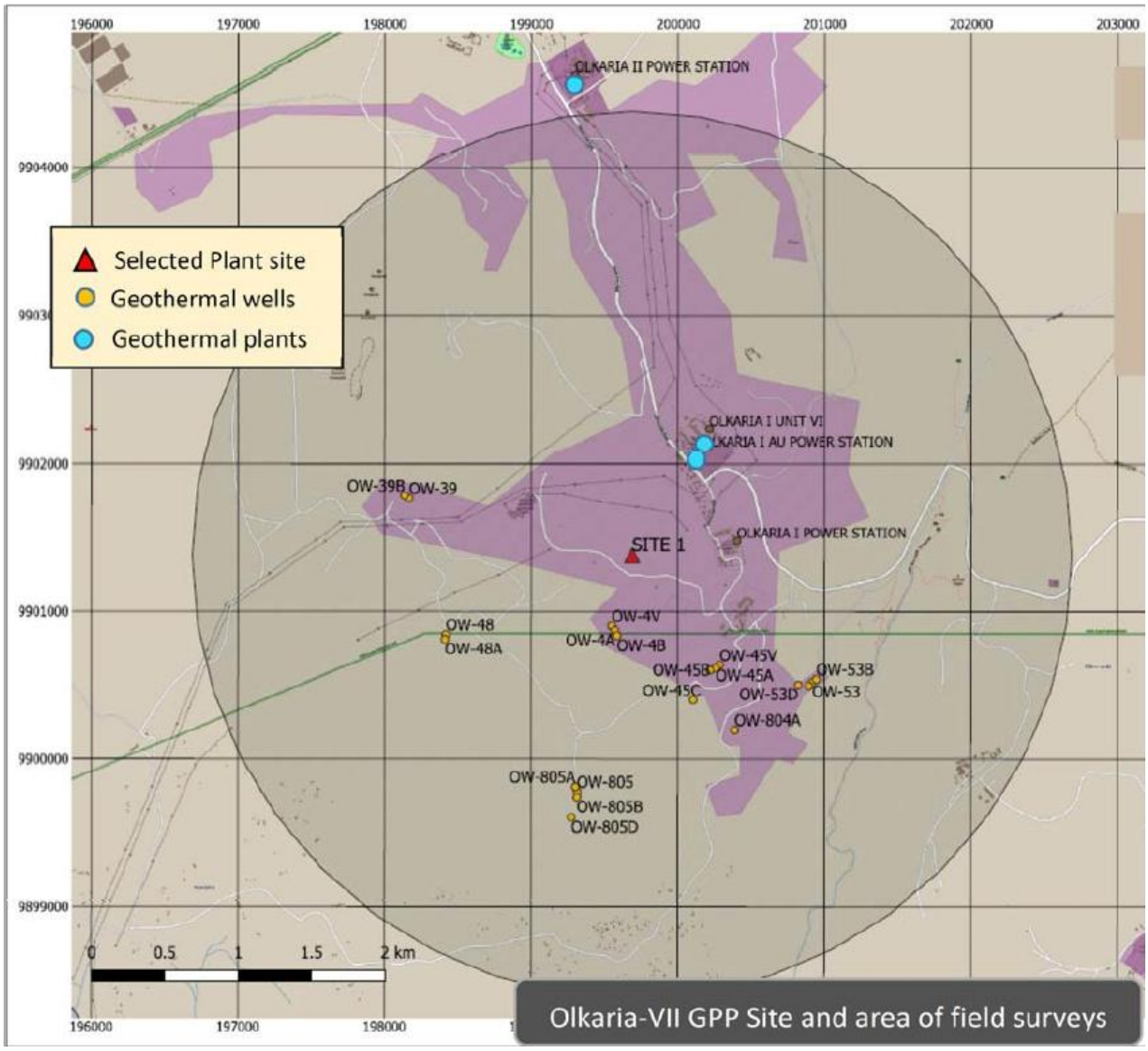
While the growing deficit of power supply may be mitigated or completely offset by increasing imports of cheap power from Ethiopia, the energy supply security of the country may be affected should the percentage of imported power rises too much, a key issue not considered in the LCPDP. Therefore, although having to pay the higher costs charged by local IPPs, it would be of best Kenyan national interest to invest efforts in developing its own indigenous resources rather than to increase economic dependence from the neighbour nations.

3.2. REVIEW OF GEOTHERMAL RESOURCES IN OLKARIA

3.2.1. Characterisation of the geothermal reservoir

Nineteen production wells and seven reinjection wells were drilled in the past and were assigned to the Olkaria VII Project. However, since two of those wells, OW-39 and OW-39B, are located within the limits of the Olkaria National Park their utilization was dismissed due environmental considerations. In order to replace the steam output, one (1) additional production well, OW-48B, recently drilled outside the national park, has been assigned to the Olkaria V Additional Unit Project.

The location of the wells can be found in Figure 3.2-1. The data of the wells acquired during the drilling campaign, the production and injection test, the heat-up survey, the well flow test, and the pressure, temperature and spinner (PTS) logging survey implemented by KenGen in the past is properly archived in the database with unified excel format. Available data provided by KenGen was reviewed and listed in Table 3.2-1 and the summary of well data is shown in Table 3.2-2.



(Source: Olkaria-VII F.S. Report)

Figure 3.2-1 Power plants and geothermal well within the range of the survey area.

Table 3.2-1 Data list of wells assigned to the Olkaria V Additional Unit Project

	Well Name	Cordinates	Trajectory	Casing Program	Downhole Data		Discharge Data
					Injection	Heat up	
Production Well	OW-4A	O	O	O	O	O	Jun 2016 - Sep 2016
	OW-4B	O	O	O	X	X	Jun 2016 - Sep 2016
	OW-4V	O	O	O	O	O	Jun 2016 - Aug 2016
	OW-45	O	O	O	O	O	Nov 2016 - Dec 2016
	OW-45A	O	O	O	O	O	Nov 2016 - Dec 2016
	OW-45B	O	O	O	O	O	Nov 2016 - Dec 2016
	OW-45C	O	O	O	O	O	Jun 2020 - Sep 2020
	OW-48	O	O	O	O	O	Mar 2015 - May 2015
	OW-48A	O	O	O	O	O	Apr 2015 - May 2015
	OW-48B	O	O	X	O	O	Dec 2024 - Mar 2025
	OW-53	O	O	O	O	O	Aug 2016 - Sep 2016
	OW-53B	O	O	O	O	O	Aug 2016 - Oct 2016
	OW-53C	O	O	O	O	O	Aug 2016 - Oct 2016
	OW-53D	O	O	O	O	O	May 2018 - Jun 2018
	OW-804A	O	O	O	O	O	Oct 2014 - Dec 2014
	OW-805	O	O	O	O	O	Aug 2014 - Sep 2014
	OW-805A	O	O	O	O	O	Aug 2014 - Sep 2014
	OW-805B	O	O	O	O	O	Aug 2014 - Sep 2014
Reinjection Well	OW-805D	O	O	O	O	O	Apr 2016 - May 2016
	OW-807	O	X	O	O	O	-
	OW-807A	O	X	O	O	O	-
	OW-R12	O	X	O	O	X	-
	OW-R13	O	X	O	O	O	-
	OW-3	X	X	X	X	X	-
	OW-11	X	X	X	X	X	-

(Study Team from KenGen data)

Table 3.2-2 Summary data of production wells assigned to Olkaria V Additional Unit

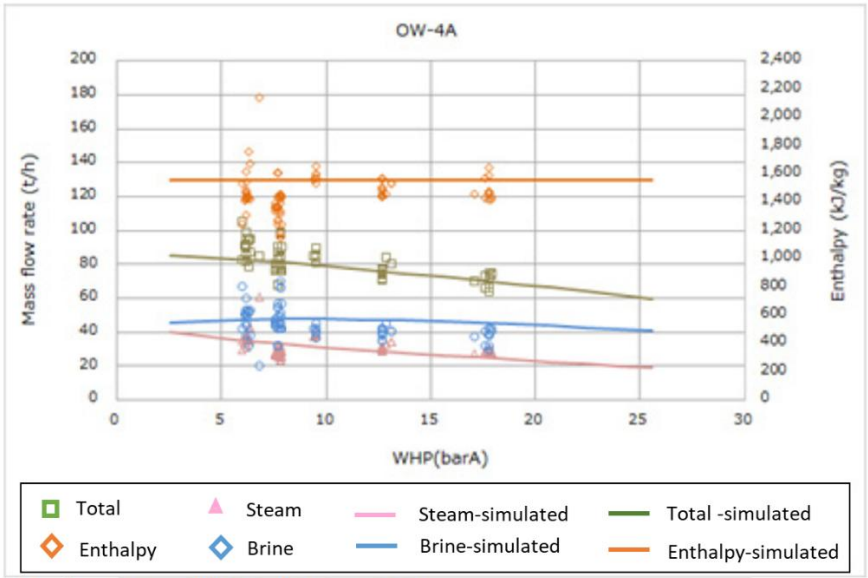
Well Name	Steam flow rate @ 11 bar t/h	Cordinates		Drilling Commissioning
		Northing	Easting	
OW-4V	32.5	9900903.408	199549.785	31.12.2015
OW-4A	34.1	900874.174	199571.222	30.06.2015
OW-4B	39.0	9900839.746	199585.573	31.12.2015
OW-45V	51.5	9900640.724	200285.663	31.01.2022
OW-45A	51.6	9900618.104	200259.697	31.05.2015
OW-45B	42.9	9900605.089	200220.196	31.12.2015
OW-48	29.3	9900846.547	198418.742	31.05.2014
OW-48A	28.6	9900815.141	198411.877	31.12.2014
OW-48B	61.0	9900892.708	198323.25	24.04.2024
OW-45C	35.0	9900403.747	200105.138	30.04.2019
OW-53	36.0	9900524.114	200918.609	31.12.2021
OW-53B	40.2	9900544.19	200945.418	31.12.2021
OW-53C	16.6	9900500.749	200894.561	31.12.2021
OW-53D	35.8	9900506.147	200822.571	30.06.2022
OW-804A	27.1	9900201.824	200388.432	31.12.2021
OW-805	28.6	9899779.926	199314.073	30.06.2013
OW-805A	43.9	9899813.987	199302.563	31.05.2014
OW-805B	50.6	9899741.061	199312.855	31.05.2014

(Study Team from KenGen data)

Based on the well data, KenGen performed the deliverability curve analysis to determine the reservoir characteristics around the wellbore of each production well. For the reinjection wells, the injection capacity estimation was implemented by reviewing the downhole pressure during step-rate injection tests and calculation of the injectivity index. These methods are commonly utilised for power plant feasibility studies since the subsurface and the surface need to be connected via wellhead.

Here, the deliverability curve analysis leads the correlation between the wellhead pressure and the flow rate and the enthalpy of the well. At the conceptual design of the Steamfield Above Ground System (SAGS), the required (or minimum) wellhead pressure is estimated to transfer the steam from the well to the power plant via the pipeline and the separator. Consequently, the steam flow rate at the certain wellhead pressure is calculated for each production well, and the total power output of the power plant will be estimated. The produced brine is transferred from the separator to the reinjection well via pipelines. The result of the injection capacity estimation of the well indicates whether there is enough capacity to inject the produced brine to reservoir via the reinjection wells.

The deliverability curve analysis was carried out by using a wellbore simulator software known as "WellSim". In the "WellSim", the wellbore model of each production well is constructed with reference to the well trajectories, casing configurations and, estimated feed zones. Then, the productivity index (P.I.) is adjusted to lead the plausible deliverability curve, matching with the measured wellhead pressure and mass flow rate. Figure 3.2-2 shows the result of the well OW-4A as one of the results. The Study Team evaluated whether the derived deliverability curves for each mass flow rate, brine flow rate, steam flow rate, and enthalpy, were properly matched with field measurement data (the dot plots). Therefore, the polynomial approximations of the derived deliverability curves can be used to determine the flow rate at certain wellhead pressure.



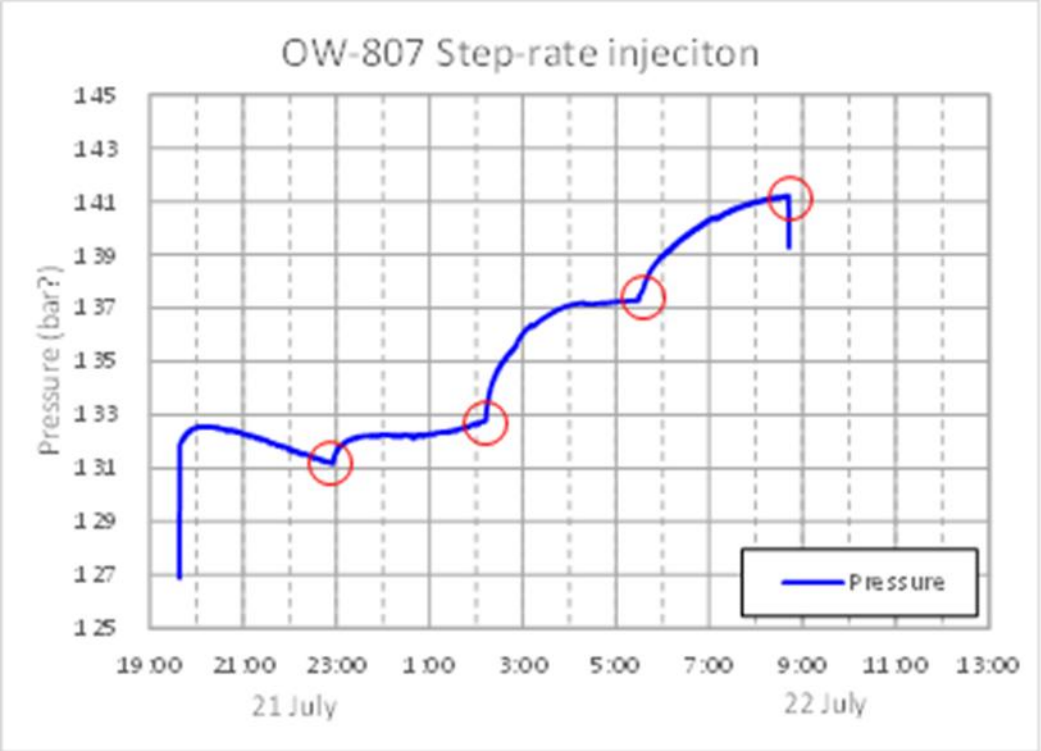
Mass flow rate: y = -0.0133x2 - 0.7443x + 87.584
Steam flow rate: y = -2.36E-06x5 + 2.03E-04x4 - 6.97E-03x3 + 1.29E-01x2 - 2.11E+00x + 4.45E+01
Brine flow rate: y = 3.59E-06x5 - 3.23E-04x4 + 1.16E-02x3 - 2.27E-01x2 + 2.01E+00x + 4.16E+01

(Olkaria-VII F.S.)

Figure 3.2-2 Deliverability curves and polynomial approximations of the well OW-4A

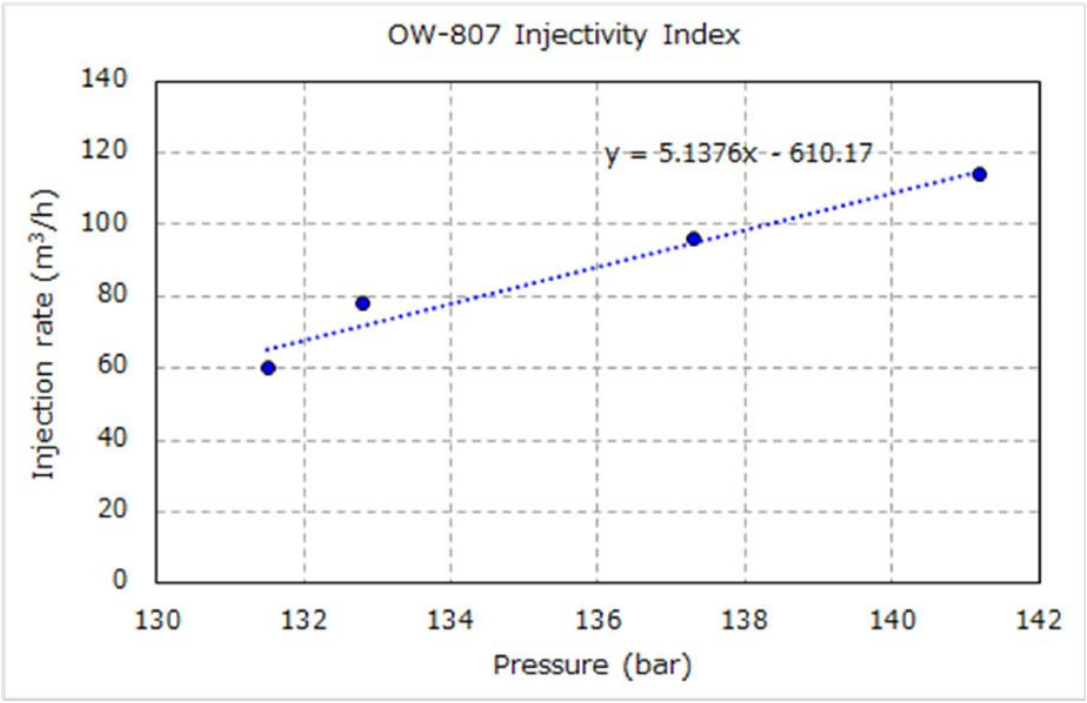
In regard the reinjection wells, firstly, the downhole pressure during step-rate injection test was plotted as shown in Figure 3.2-3 (well OW-807). Following, the downhole pressure of each injection rate at stable point was plotted, as shown in Figure 3.2-4, which lead to calculate the injectivity index as 5.1 m^3/h/bar. Finally, the horizontal axis was converted to the difference of water level to find out the injection capacity, as shown in Figure 3.2-5. The measured water level of well OW-807 was 420m; therefore, the injection capacity was estimated at 161 t/h. The summary of the injectivity index of each reinjection well is shown in Table 3.2-3.

The Study Team confirmed that the above evaluation results of reservoir characteristics by KenGen were based on field measurement data and through commonly used analytical methods in geothermal resource assessment.



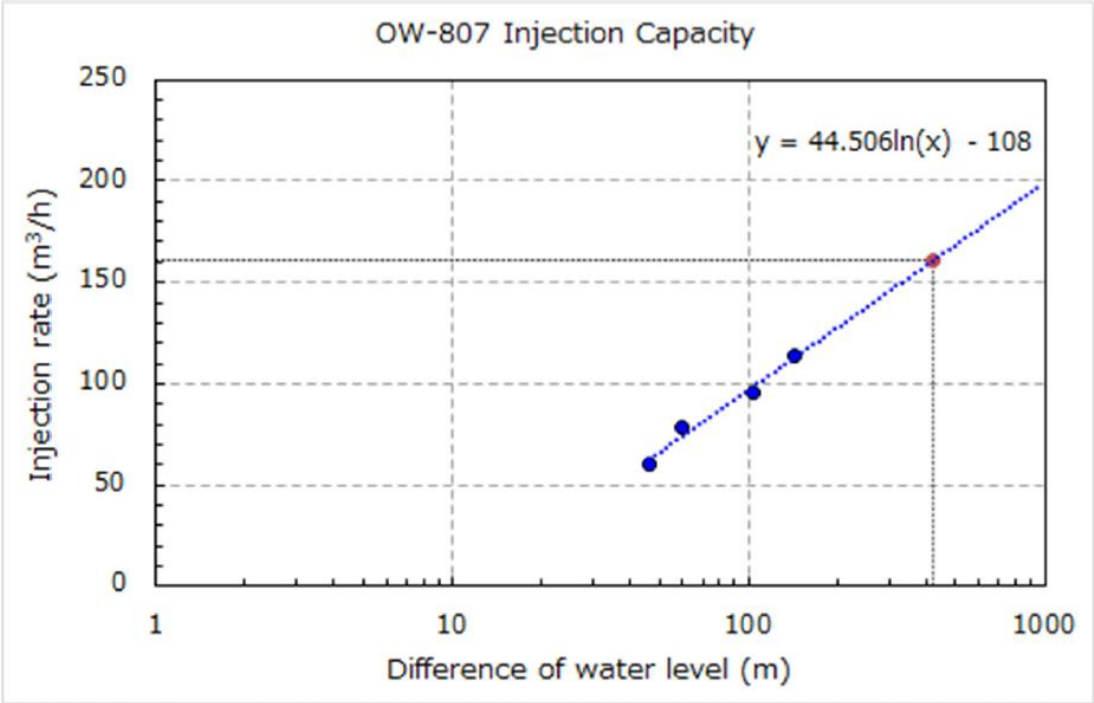
(Study Team)

Figure 3.2-3 Downhole pressure profile during the step-rate injection test of the well OW-807



(Study Team)

Figure 3.2-4 Calculation of the injectivity index of well OW-807



(Study Team)

Figure 3.2-5 Estimation of reinjection capacity of well OW-807

Table 3.2-3 Summary of reinjection capacity of wells

Well	Injectivity index [t/h/bar]	Injection Capacity @water level [t/h]	Injection Capacity @11.5 bar [t/h]
OW-807	5.1	161	171.6
OW-807A	6.2	175	205.4
OW-R12	9.0	181	198.0
OW-R13	22.0	151.4	154.8
OW-805D	=	198	=
OW-3	=	150 (*1)	=
OW-11	=	150 (*1)	=
Total	**=**	**1,166**	**=**

(*1)：The injection capacities of OW-3 and OW-11 are assumed similar to OW-R13 due to data unavailability. Other data (=) is not available either.

(Source: Olkaria-VII F.S. Study Team)

3.2.2. Evaluation of future steam production and power output

Based on the derived deliverability curve and the polynomial approximations, KenGen calculated the initial flow rate of each production well at the arbitrary wellhead pressure provided by the SAGS engineering. Table 3.2-4, in next page, shows the summary of the estimated initial flow rate of each production well.

The estimated total steam flow rate from the existing 18 production wells, assuming arbitrary wellhead pressure, was 600 t/h excluding the non-condensable gases (hereinafter, NCG). The required steam flow rate to generate 80.3 MW gross electricity output level is 477.6 t/h excluding the NCG, as calculated through the engineering of power plant. The initial steam flow rate has approximately 20% margin of the required volume.

In a subsequent step, KenGen performed the forecast calculation and the sensitivity analysis relevant with the number of make-up production wells required after COD.

KenGen assumed decline rates of 1.5 %/year, 2.0%/year and 2.5%/year. As a reference, the MANVIT / ISOR / VATNASKIL / VERKIS report "Revision of the Numerical Model of the Greater Olkaria geothermal system" (2017) establishes the decline rate of Olkaria I at 0.5%/year, Olkaria I AU 4, 5 and 6 at 1.5 %/year, and, of Olkaria II, Olkaria IV and Olkaria V at 1.5%/year. KenGen assumed the higher decline rate because of the uncertainties comparing to other near fields.

The steam supply margin was assumed 0%, 10%, and 20% over a Project life span set as 25 years and for the reference of the economic feasibility calculations. The summary of the sensibility analysis is shown in Table 3.2-5.

The Study Team confirmed that the forecast calculations by KenGen were carried out properly by adding make-up wells at the appropriate timing such to sustain the required steam flow rate for 25 years.

After the sensitivity analysis, in order to further move into the stage of surface facilities and economic feasibility study, KenGen selected the following development scenarios:

- COD with 18 existing production wells.
- 7 make-up production wells are added sequentially to maintain the steam production level above 477.6 t/h required to generate 80.3 MW gross of power output keeping yet an adequate margin (6%) of steam supply.
- The initial steam flow rate of each make-up production well is assumed as 30 t/h, which is almost average of 18 existing production wells (32.5 t/h).
- The assumed decline rate is 2.0%/year for 25 years Project life span.

In this scenario, the brine flow rate was estimated at approximately 680 - 810 t/h for 25 years after COD. As shown in Table 3.2-3, the capacity of the seven (7) existing reinjection wells seems to be enough to inject the whole brine back to the reservoir assuming the confirmation of the reinjection capacity condition of wells OW-3 and OW-11.

The Study Team evaluated that the above results by KenGen seem to be conservatively feasible at this stage, although there are several conditions to confirm. The reason for the conservatively feasible assessment is the following.

- Six percent (6%) margin equals the steam production amount of 28 t/h, i.e., one well production volume.
- At the later section of this Report, the capacity factor and the availability factor of the power plant are assumed as 85% and 95%, respectively. Since the above steam availability forecast calculation is based on both 100% for capacity factor and availability factor then there is some more margin of steam availability.

Table 3.2-4 Required wellhead pressure and initial production flow

Separator	Production Wells	WHP [bara]	Steam Flow [t/h]	Brine Flow [t/h]	Mass Flow [t/h]
SV-100	OW-48	11.7	23.6	32.4	56.0
	OW-48A	11.7	21.2	73.9	95.1
	OW-48B	11.6	61.0	2.8	63.8
	OW-805	11.3	18.7	89.4	108.1
	OW-805A	11.4	37.7	62.9	100.6
	OW-805B	11.5	42.2	138.4	180.6
SV-101	OW-4V	12.6	30.7	15.4	46.2
	OW-4A	12.6	28.8	47.3	76.1
	OW-4B	11.7	36.3	93.3	129.7
	OW-45V	11.7	39.5	27.1	66.6
	OW-45A	12.1	41.5	27.1	68.6
	OW-45B	12.0	41.8	12.8	54.5
	OW-45C	12.0	30.8	68.9	99.8
	OW-804A	11.2	25.5	20.1	45.5
SV-102	OW-53	10.7	37.5	3.3	40.8
	OW-53B	10.6	32.4	58.3	90.7
	OW-53C	10.6	17.8	5.6	23.4
	OW-53D	10.6	32.9	27.7	60.6

(Study Team from KenGen data)

Table 3.2-5 Sensitivity analysis on the number of required make up production wells

Condition		Project life span (yearly decline rate)		
		25 years (1.5%)	25 years (2.0%)	25 years (2.5%)
A	20% margin (Start with 19 wells)	10 make up wells	14 make up wells	18 make up wells
B	10% margin (Start with 19 wells)	7 make up wells	10 make up wells	14 make up wells
C	10% margin (Start with 17 wells)	7 make up wells	10 make up wells	14 make up wells
D	0% margin (Start with 19 wells)	4 make up wells	7 make up wells	11 make up wells
E	0% margin (Start with 16 wells)	3 make up wells	6 make up wells	10 make up wells

(Source: Olkaria-VII F.S. Report)

3.2.3. Recommendations on the forecasted estimation results

Recommendations are the following:

Since the steam condensate is planned to be reinjected into the reservoir at or near well pad OW-801 through a newly drilled well; the injection capacity estimation of the new cold condensate reinjection well shall be completed as soon as possible.

The flow rate to reinject has been estimated at about 118.5t/h, as depicted in Table 3.3-3 and Figure 3.3-12 in section 3-3. In addition, injection capacity tests on wells of OW-805D, OW-3 and OW-11 shall be completed as soon as possible.

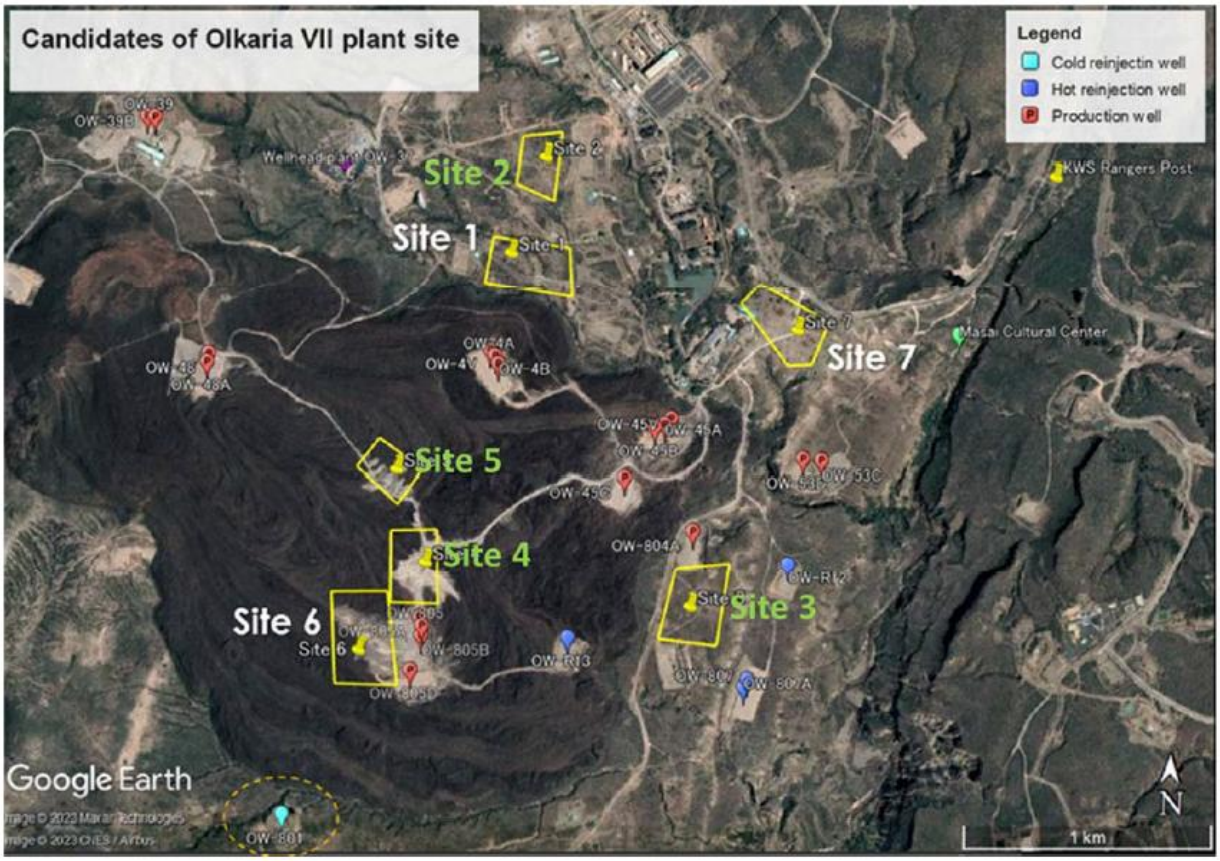
Numerical simulation of the reservoir shall be implemented to confirm the steam supply forecast more precisely and to understand the interference between the production wells and the reinjection wells.

3.3. REVIEW OF SURFACE FACILITIES

3.3.1. Review of Power Plant

(3) Siting of Power Plant

Seven candidate sites for the Olkaria V additional unit were evaluated, taking into consideration environmental, social, technical and economic factors, and Site 1 shown in Figure 3.3-1 was recommended. The details of the evaluation are as follows:



(Source: Olkaria-VII F.S. Report)

Figure 3.3-1 Seven candidate sites for Olkaria V Additional Unit

Seven candidate sites were initially evaluated. Of these, Site 2, Site 3, Site 4, and Site 5 were deemed unsuitable for the following reasons:

- Site 2 is located within the national park.
- Site 3 is close to communities to the south and Ol Njorowa Gorge (a tourist attraction) to the east.
- Site 5 and Site 6 are in the lava areas with very uneven terrain, which is expected to pose difficulties in terms of civil engineering work.

A final evaluation was carried out for the remaining Sites 1, 6, and 7. In the final evaluation, emphasis was placed on environmental and social aspects and their points weighed twice as much as other elements of the other criteria (Table 3.3-1).

The results of the evaluation are shown in Table 3.3-2. In this, Site 1 was given 49 points compared to Site 6 (43 points) and Site 7 (44 points), indicating that Site 1 is the most suitable location for the installation of power generation facilities. The following briefly discusses the evaluation of each item.

- **Environmental:** Site 1 received 19 points, indicating minimum environmental impact compared to the other sites. Sites 6 and 7 received lower scores due to their proximity to wildlife habitats and communities.
- **Local community:** Site 1 received 8 points, reflecting less community-related concerns. On the other hand, since Site 6 is located relatively close to the nearest community (about 800m away) it prompted concerns about impacts on the community and received lower scores. Site 7 received a slightly lower score due its proximity to the Maasai Cultural Center and the KWS Ranger Post.
- **Distance to the National Park:** Sites 1 and 7 are close to the south border of the Hell's Gate National Park (approximately 200 m), whereas Site 6 is farther away (approximately 1700 m).
- **Civil works:** Sites 1 and 7 both received 22 points, indicating no particular obstacles for the implementation of civil works, including earthworks, retaining walls and stormwater drainage. However, Site 6 received a lower score due to the rugged terrain, which would require significant civil works.
- **Availability of flat land:** The terrains of Site 1 and Site 7 are suitable for construction and received 3 points each, but the terrain of Site 6 is rough and only received 1 point.
- **Future expandability:** Site 6 holds the largest area available for expansion allowing to plan an additional unit in the future, therefore, was given 4 points. Sites 1 and Site 7 do also have area for expansion and were given 3 points each.
- **Pipeline:** Site 7 is far from the production wells, which is disadvantageous in terms of pipeline construction costs, performance (pressure loss), and relocation costs of the existing pipeline; hence, the score resulting from its evaluation was low.
- **Cost:** Site 1 has the highest estimated cost for aboveground facilities other than the power plant itself, but the difference does not have a decisive impact.

Table 3.3-1 Scoring criteria for final selection of power plant site

	Evaluation weight (score points)	
CRITERIA for Plant construction	SAGS construction, Civil engineering, Transmission line	Social-environmental constrictions
Easy to implement, no-problems perceived, low costs, recommended, limited environmental impact	4	8
(in between directly-above and below Criteria)	3	6
Possible / Fair / manageable for implementation/ Reasonable costs/ mitigatable environmental impact	2	4
(in between directly-above and below Criteria)	1	2
Impractical, high costs, high environmental impact	0	0

(Source: Olkaria VII F.S. Report)

Table 3.3-2 Ranking Matrix for the selection of the most suitable location for plant siting

SUBJECT	Site 1	Site 6	Site 7
Environmental concerns	**19**	**12**	**11**
Local Community issues	8	2	4
Proximity to the National Park	3	4	2
Visual impacts	3	2	1
Noise pollution	3	2	2
H2S contamination	2	2	2
Civil engineering	**22**	**17**	**22**
Availability of flat space	3	1	3
Space for future expansion	3	4	3
Drainage - catchment area	3	4	3
Easiness of access -murram or tarmac road	4	2	4
Soil stability (erosion, land slide)	3	3	3
Proximity to geological fault	3	1	3
Water supply	3	2	3
Pipelines construction	**5**	**8**	**5**
Interference with existing facilities	3	4	2
Condensate reinjection	2	4	3
Transmission line	**2**	**4**	**3**
Interference/proximity with existing transmission lines and substation	2	4	3
Preliminary Costs (all in million US$)	**1**	**2**	**3**
Cost for environmental mitigation measures	0.2	1.3	0.2
Cost of civil works – earthworks, retaining walls, water storm drains	1.8	4.6	1.3
Pipelines cost including removal of existing	31.66	26.66	28.48
Additional production wells for 140MW (net)	88.9	82.2	85.1
Cost for transmission line	5.0	10.8	6.2
Total estimated Cost	127.6	125.6	121.8
Total score	**49**	**43**	**44**

(Source: Olkaria VII F.S. Report)

(4) Generation Technology

After comparing five power generation technologies considered suitable for the geothermal resources of this Project, Option 1 is recommended as the most suitable option due to its efficiency, economics, and low operational risk (Table 3.3-3).

The five power generation methods compared are as follows:

Option 1: Single flash cycle condensing steam turbine with wet-cooling tower, 1 unit

Option 2: Single flash cycle condensing steam turbine with wet-cooling tower, 2 units

Option 3: Single flash cycle condensing steam turbine with hybrid-cooling tower

Option 4: Combination of backpressure turbine and bottoming ORC (Organic Rankine Cycle) unit

Option 5: Two-phase binary power plant

The evaluation criteria are as follows:

- Net power output (MW)
- Power plant cost (CAPEX)
- Unit cost (construction cost divided by net power output (USD/kW))
- Risk (technical complexity and maintainability)

The design conditions assumed are the following:

- Steam flow: 80% of the mass flow obtained from the production wells allocated to this Project (considering initial margin)
- Non-condensable gases (NCG) diluted in the steam: 1.0% wt.
- Design wet-bulb temperature for wet cooling tower: 18°C (90 percentile of observed data near Olkaria II Power Plant (August 2015 to August 2016) plus a margin of 1°C)
- Design dry-bulb temperature for air-cooled condenser: 25°C (same as above)
- Steam pressure at the power plant inlet: Based on the deliverability curve at the power plant inlet calculated from each production well data and the pressure loss of the pipeline system, the pressure at which the net output is maximized is selected for each option.

Table 3.3-3 Comparison of proposed power generation technologies

	Option 1	Option 2	Option 3	Option 4	Option 5
Generation technology	Single-flash cycle with condensing steam turbine	Single-flash cycle with condensing steam turbine	Single-flash condensing steam turbine	Combination of backpressure steam turbine and ORC	Two-phase binary
Number of units	1 STG	2 STG	1 STG	1 STG + 2 ORC	2 ORC
Cooling system	Wet cooling tower	Wet cooling tower	Hybrid cooling tower (dry section heat load 10%)	Air cooled condenser	Air cooled condenser
Gross output (MW)	80.30	80.30	80.30	60.78	64.58
Net output (MW)	**76.14**	**76.14**	**75.14**	**56.44**	**54.41**
Steam supply pressure (bara)	9	9	9	11	10
Steam flow (t/h) excl. NCG	477.6	477.6	477.6	453.6	465.6
Brine flow (t/h)	804.8	804.8	804.8	782.4	793.6
Condensate recovered (t/h)	118.5	118.5	152.6	451.9	463.0
Fluid recovery rate	72.0%	72.0%	74.7%	99.9%	99.8%
ADVANTAGES	Highest net output		High net output	Nearly 100% fluid recovery	
	O&M well-known by KenGen (technology of existing plants)		No cooling tower plume (less visual impact, corrosion, etc.)	ACC in use. No plume from cooling tower (less visual impact)	
	Lowest cost	Operation flexibility	Increased fluid recovery	-	No H_2S emission
	Low risk of scaling	Low risk of scaling	Low risk of scaling	Low risk of scaling	-
DISADVANTAGES	-	Higher cost	Higher cost	Higher cost	Highest cost
	-	-	The dry section of the cooling tower demand increased maintenance effort	Lower net output	Lowest net output
	-	-	Cooling tower may need larger space	ACC requires a large area (No space for future extension)	
	-	-	-	-	Need a NCG injection compressor for brine pH control
	-	-	-	-	Need a brine booster pump

(Source: Olkaria VII F.S. Report, modified by Study Team)

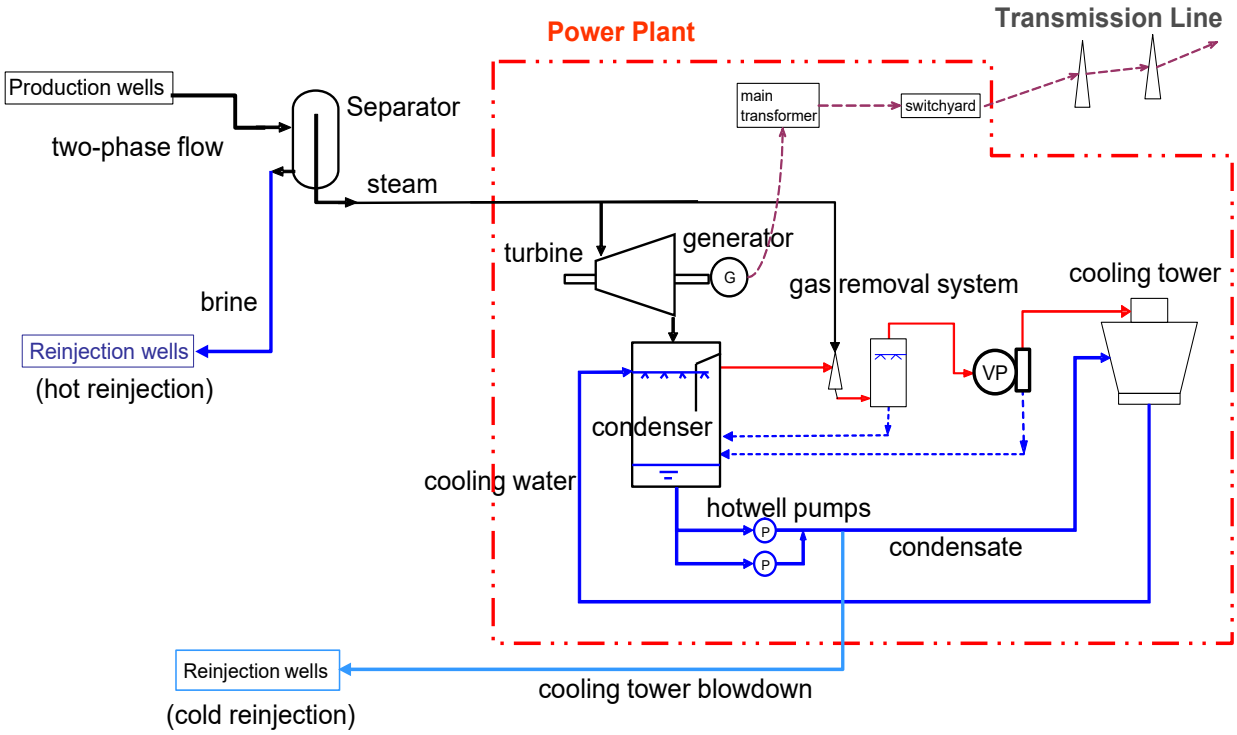
(a) Option 1: Single flash cycle condensing steam turbine - wet cooling tower - one (1) unit

In this option, the mixture of steam and hot water (two-phase fluid) from the production wells is separated into steam and hot water (brine) at separators. The brine is sent directly to the reinjection wells. The steam is sent to the power plant, where it drives the steam turbine generator, and is then cooled in the condenser to become condensate, which is then sent to a wet cooling tower where it is cooled by contact with air and reused as cooling water. The non-condensable gases in the steam are extracted from the condenser by steam jet ejectors and liquid ring vacuum pumps and are released through the updraft from the cooling tower fan. Refer to Figure 3.3-2.

As it is shown in Table 3.3-3, among the five options analysed, this option has the highest net output (76 MW) and the lowest construction costs.

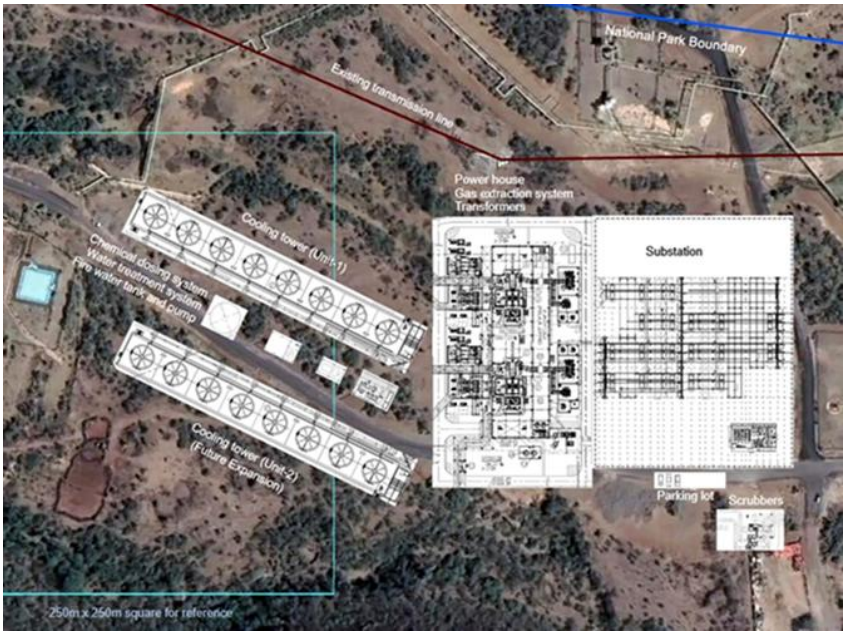
This power generation technology is utilized in the Olkaria II, Olkaria I Units 4-6, Olkaria IV and, Olkaria V Unit 1 and Unit 2. KenGen has long experienced the single flash technology at those power plants, therefore, plant operation and maintenance should be much easier to implement. In addition, space can be secured for the future expansion of the Plant installing an additional Unit (refer to Figure 3.3-3).

The risk of silica scaling is low in Options 1 to 4 because the brine is reinjected at high temperature.



(JICA Supplementary F.S. Study Team)

Figure 3.3-2 Conceptual process flow of Option 1



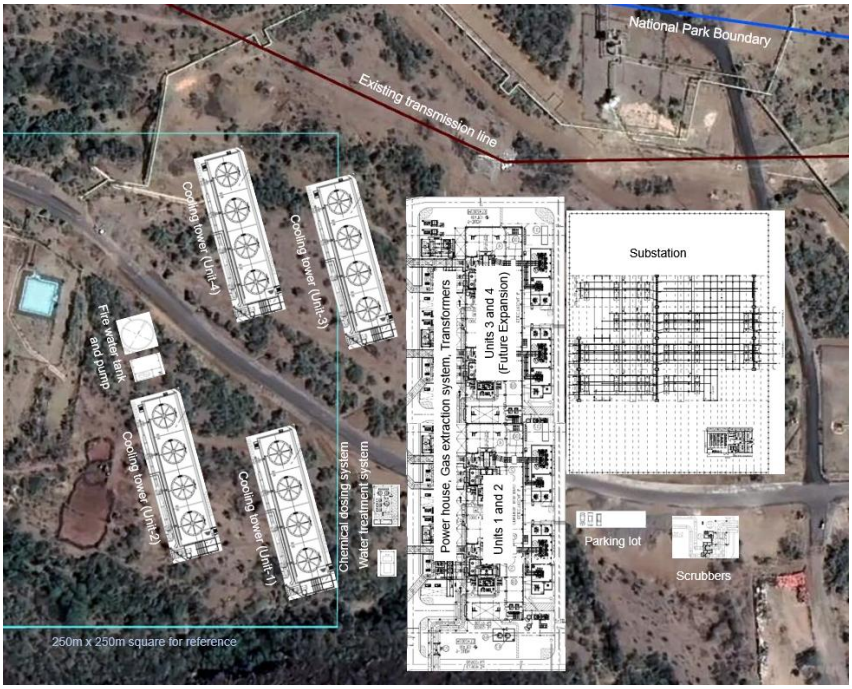
(Source: Olkaria VII F.S. Report)

Figure 3.3-3 Conceptual plant layout of Option 1 including its future expansion

(b) Option 2: Single flash cycle condensing steam turbine -wet-cooling tower- 2 units

The power generation technology and output are the same as in Option 1; however, since the capacity of each individual unit will be one-half of the 80.3MW planned, economies of scale will not be obtained, and construction costs will be higher.

There is a possibility that operational flexibility will increase, but maintenance costs may increase. As the turbine building will be larger and the number of cooling towers will also increase, a larger site area will be required than in Option 1 to accommodate future expansion, resulting in higher civil work costs (Figure 3.3-4).

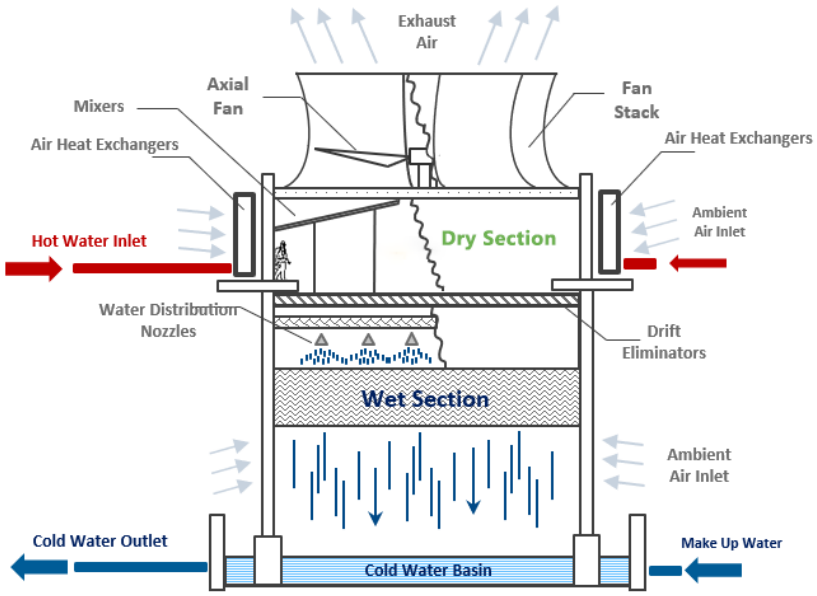


(Source: Olkaria VII F.S. Report)

Figure 3.3-4 Conceptual plant layout of Option 2 including its future expansion

(c) Option 3: Single flash cycle condensing steam turbine and hybrid cooling tower

The power generation technology and layout are the same as in Option 1, but a wet-dry hybrid cooling tower is adopted to increase the recovery of geothermal steam condensate for the purpose of reservoir recharge (i.e., to reduce the cooling water evaporation loss in the cooling tower). The wet-dry hybrid cooling tower assumed in the existing F/S handles about 10% of the heat load with the air-cooled heat exchanger placed on top of the wet cooling tower (Figure 3.3-5). As the required cooling tower air volume (fan power) is larger, the net output is about 1 MW lower than in Option 1, at about 75 MW. In addition, the construction cost of the cooling tower will be higher, and the air-cooled heat exchanger will be a factor in increasing maintenance costs.

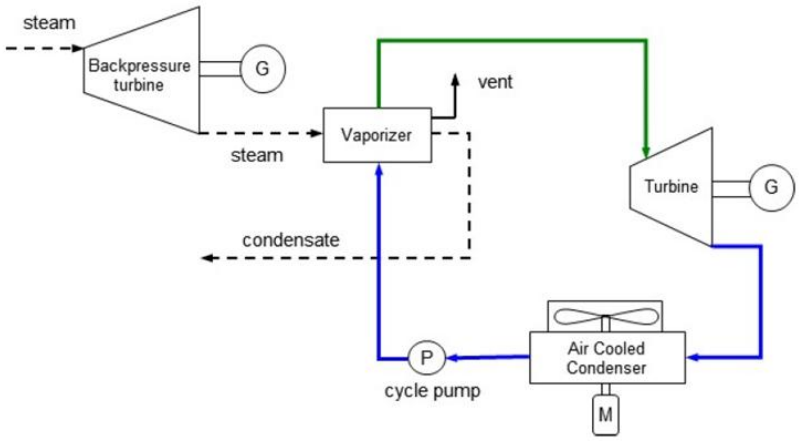


(Source: Olkaria VII FS Report (www.babcock.com))

Figure 3.3-5 Hybrid cooling tower cell

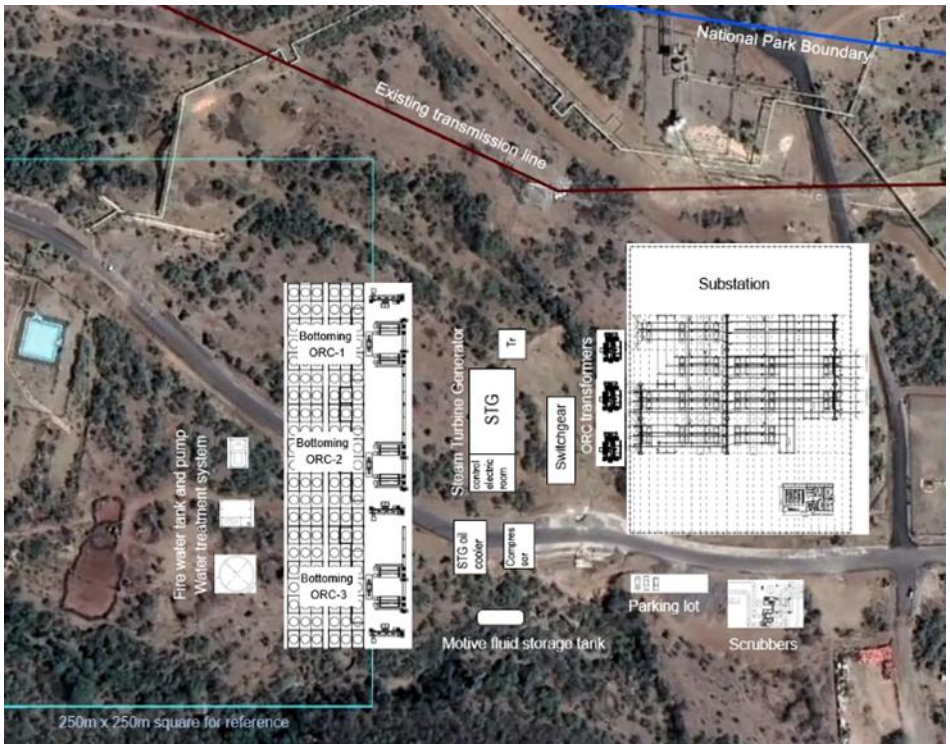
(d) Option 4: Combination of back-pressure turbine and ORC

In this system, the geothermal steam first spins a steam turbine-generator set; following, the thermal energy (latent heat) of the steam is recovered through heat exchangers of the ORC units, where from the resulting condensed fluid is sent to the condensate reinjection wells. Meanwhile, the organic medium (pentane, etc.) vapor heated in the heat exchanger drives another turbine generator. This is cooled in air-cooled condensers (ACC) where become liquid which is circulated to the heat exchanger again (Figure 3.3-6). KenGen does not have experience in operating this technology; therefore, operation and maintenance risk would be higher than utilizing Option 1 or Option 2. Due capacity limitations of the ORC equipment, one backpressure steam turbine and three ORC units would be combined; however, the large footprint of the air-cooled condenser does not allow room for future expansion (Figure 3.3-7). In addition, the high ambient temperature makes thermal efficiency lower with net output at only 56.4 MW, about 10 MW lower than Option 1.



(Source: Olkaria VII F.S. Report)

Figure 3.3-6 Conceptual process flow of Option 4

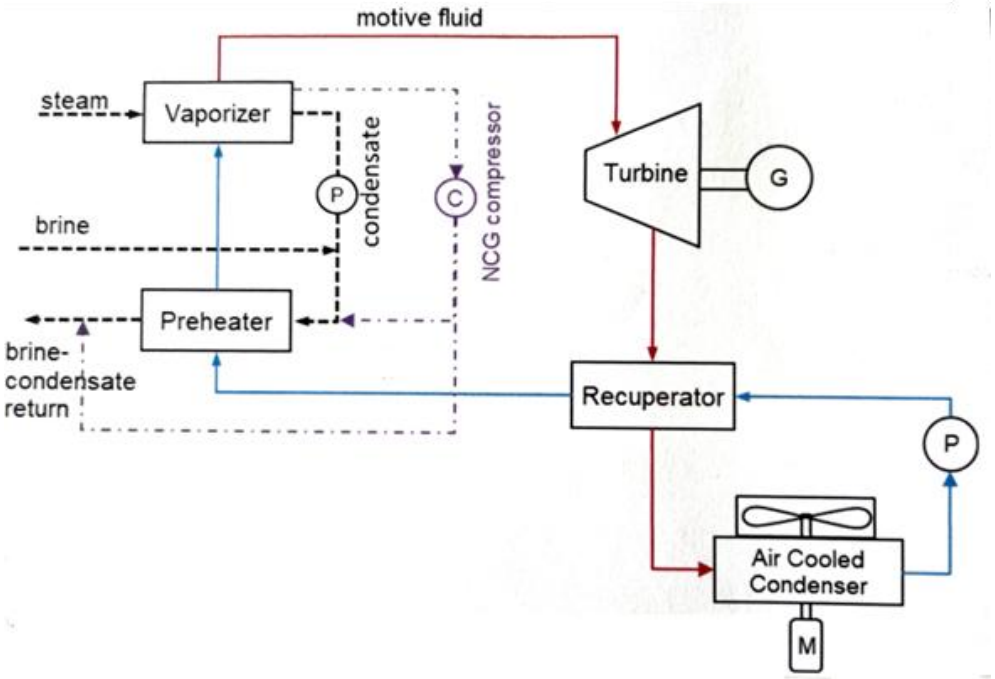


(Source: Olkaria VII F.S. Report)

Figure 3.3-7 Conceptual plant layout of Option 4

(e) Option 5: Two-phase binary power plant

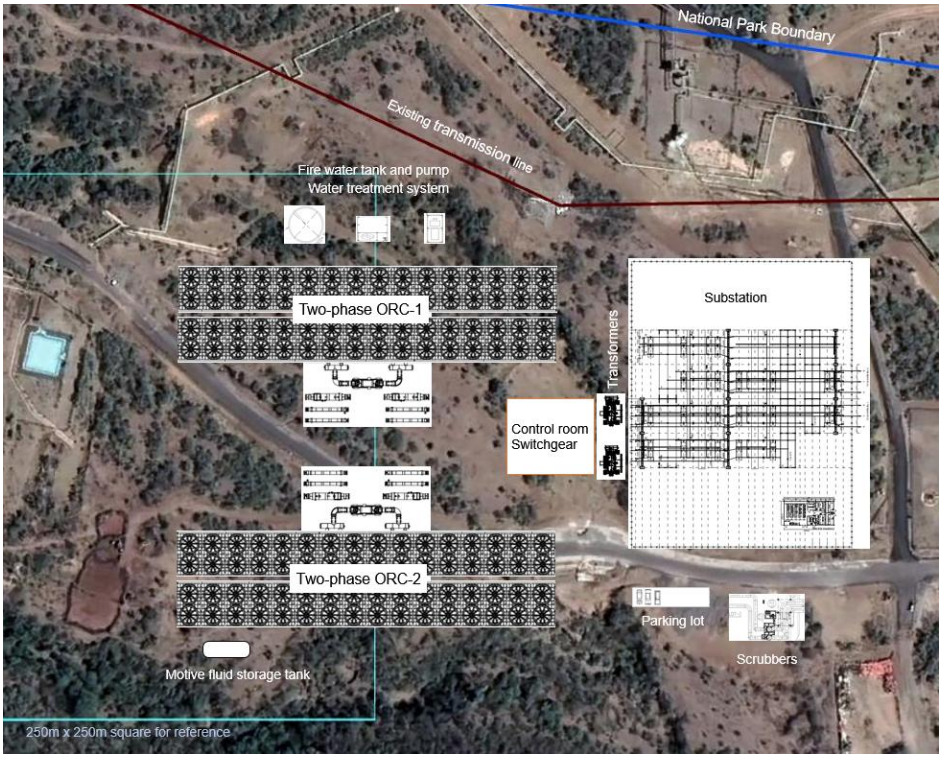
In this option, the thermal energy (latent heat) of the geothermal steam is recovered in heat exchangers (evaporators) and becomes condensate, which is mixed with hot brine and the thermal energy (sensible heat) is recovered in preheaters and sent to the reinjection wells at about 80°C. Meanwhile, the steam of the organic medium (pentane, etc.) heated in the heat exchangers drives ORC turbine generators, is cooled in air-cooled condensers and becomes liquid, and is circulated back to the heat exchangers (Figure 3.3-8). KenGen has no experience in operating this type of technology, and the need for a hot brine booster pump to transport brine from the separator SV-102 at well pad OW-53 to the power plant increases the risks in terms of operation and maintenance of this option.



(Source: Olkaria VII F.S. Report)

Figure 3.3-8 Conceptual process flow of Option 5

Figure 3.3-9 shows the conceptual layout for Option 5. It would be a two-unit configuration based on the capacity of existing power generation equipment of the same type. The installation area of the air-cooled condenser would be large and not allowing area for future expansion. In addition, the thermal efficiency would not be satisfactory due to the high ambient temperature. The estimated net output would only reach 54.4 MW, about 12 MW less than Option 1.



(Source: Olkaria VII F.S. Report)

Figure 3.3-9 Conceptual plant layout of Option 5

(5) Conceptual design of power plant

(a) Layout of Power Plant

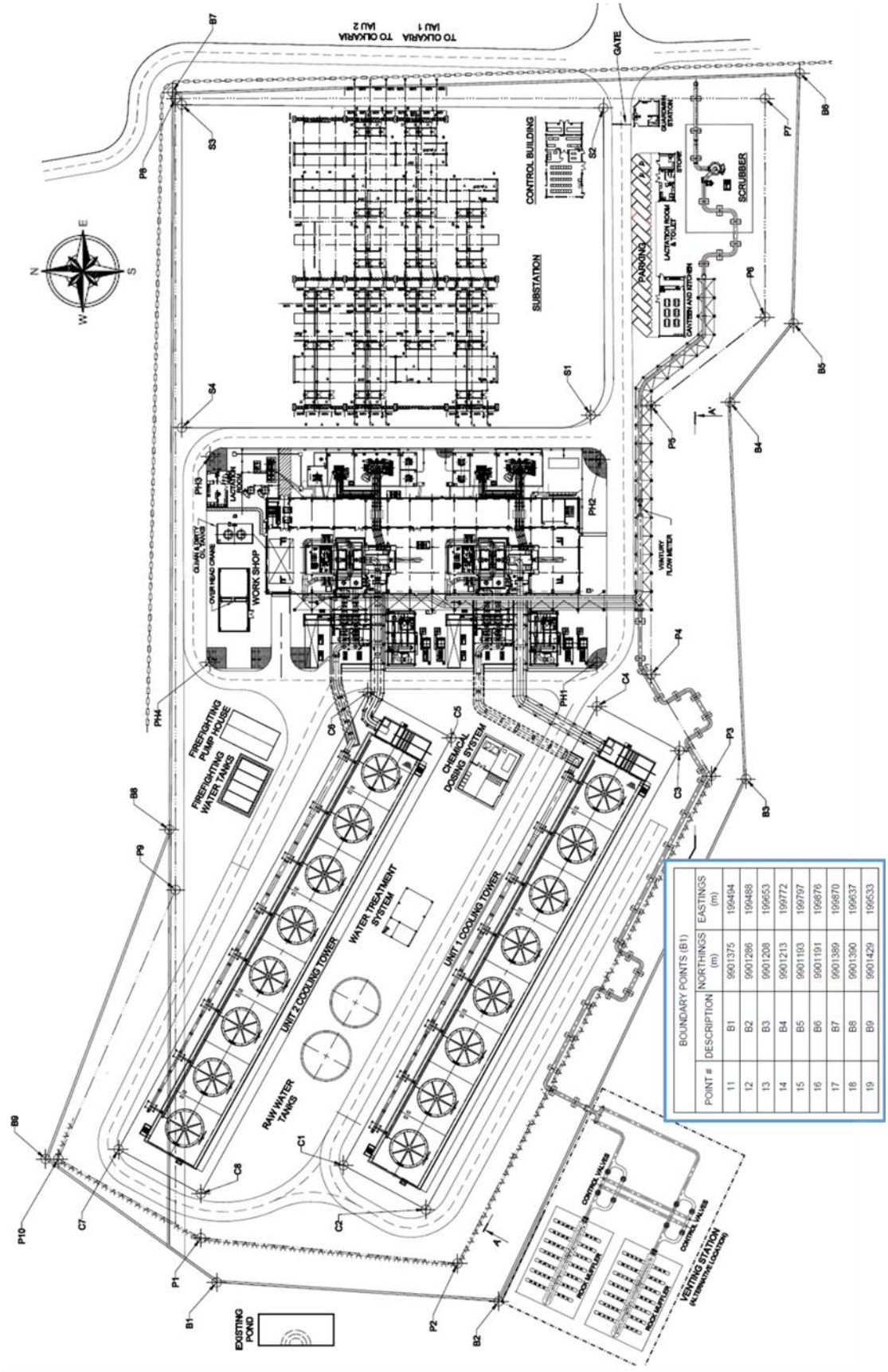
Figure 3.3-10 shows the proposed layout of the power plant in two-unit configuration. Unit-1, the Olkaria V Additional Unit, will be constructed at the southern portion of the Site, as envisioned through this Project with the substation (switchyard) located on the east side. The total site size is approximately 380 m x 200 m with the northern half reserved for Unit-2.

Any eventual expansion of the plant with another generation unit will have to consider not only the construction of electromechanical systems and cooling tower. In addition, it will also have to address additional earthworks, site internal roads, powerhouse enlargement and, to deal with the interference of the existing piping of well OW-36, located at the north-west corner of the Site.

Both generation units would be installed inside an enlarged powerhouse with respective annex for electrical room and control room. Common facilities would include the firewater tank, fire pump house, water treatment system, chemical dosing system, and substation area.

Since the production wells are distributed south to east, the piping transporting steam to the plant comes from the southeast direction. For this reason, the scrubber will be placed at the southeast part of the plant site. Since the prevailing wind in the area blows from the SSE direction most of the year, the substation will be placed on the east side of the powerhouse and the cooling towers placed on the opposite side, so that the plume from the cooling towers will not fall onto the powerhouse and the substation. The cooling tower will be placed diagonally along wind direction as much as possible while maximizing the distance from existing transmission lines and the national park boundary.

Any detour road will not be required because there is an existing road that can be upgraded to serve well pad OW-36 and the venting station. The existing natural storm channels, which serves a sizeable catchment area, will have to be relocated using concrete culverts.



BOUNDARY POINTS (B1)			
POINT #	DESCRIPTION	NORTHINGS (m)	EASTINGS (m)
11	B1	9901375	199494
12	B2	9901286	199488
13	B3	9901208	199653
14	B4	9901213	199772
15	B5	9901193	199797
16	B6	9901191	199876
17	B7	9901389	199870
18	B8	9901390	199637
19	B9	9901429	199533

(Source: Olkaria VII F.S. Report)

Figure 3.3-10 Proposed layout of the power plant including future expansion

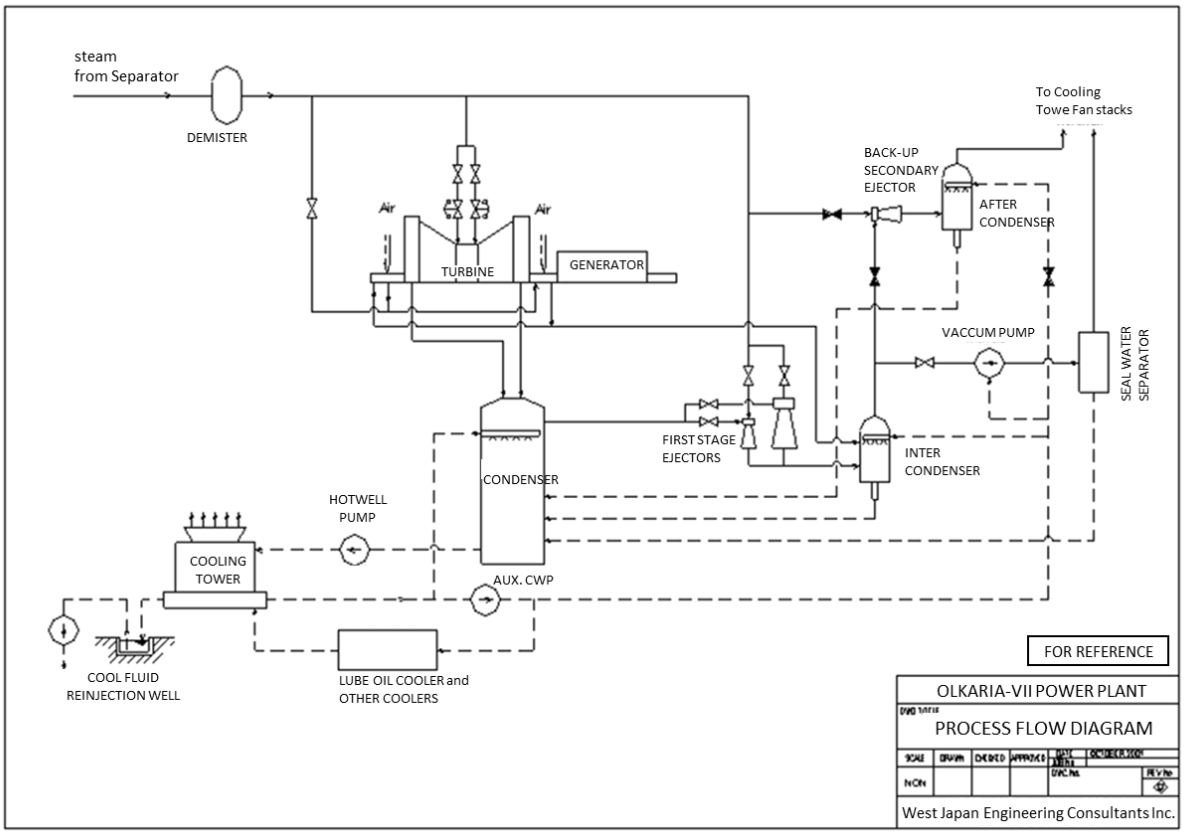
The two locations the Feasibility Study suggests for Venting Station for releasing steam are adequate for the purpose. For the sake of attaining a compact installation it would be better located at the south-west corner of the Site.

(b) Outline of process at the Power Plant

Figure 3.3-11 shows a schematic diagram of the power plant. Geothermal steam from the separator passes through a scrubber, strainer, main steam stop valve and, a control valve before entering the steam turbine. After passing through the steam turbine, the steam enters the condenser. In the condenser, the steam is cooled by contacting with cooling water from the cooling tower basin and becomes condensate. The mixture of condensate and cooling water (hot water) is pumped to the cooling tower, where it is cooled and reused as cooling water.

Non-condensable gases (NCGs) contained in the geothermal steam (including CO_2, H_2S and others) are sucked out from the condenser by the gas removal system consisting of steam jet ejectors and vacuum pumps and sent to the cooling-tower fan stacks. At the stacks, the NCGs become mixed with the large amount of warm air discharged upward from the cooling tower fans and diffused into the atmosphere. The steam utilised for driving the steam jet ejectors is branched off from the main steam pipe.

The cold water collected in the cooling tower basin is used not only to cool the condenser, but also as cooling water for the turbine lubricating oil, generators, control air compressors and gas extraction system. Excesses of condensate and cooling water are pumped to the reinjection platforms where from these fluids are returned to the underground through the reinjection wells.



(Source: Olkaria VII F.S. Report)

Figure 3.3-11 Plant Process Flow Diagram (preliminary)

(c) Power Plant Equipment

1. Power Plant Design Parameters

In the Olkaria VII FS report, the optimum steam pressure that maximizes the power output was determined based on the results of the geothermal resource evaluation and the results of the pressure loss calculation of the SAGS. As a result, the design conditions of the power plant were set as follows.

a. Steam conditions

Pressure:	9.0 bar (abs)
Temperature:	175.2 ˚C
NCG content:	1.0%wt.

b. Altitude and weather conditions

Design wet bulb temperature:	18 ˚C
Altitude:	1,963.5 MASL
Atmospheric pressure:	0.8 bar (abs)

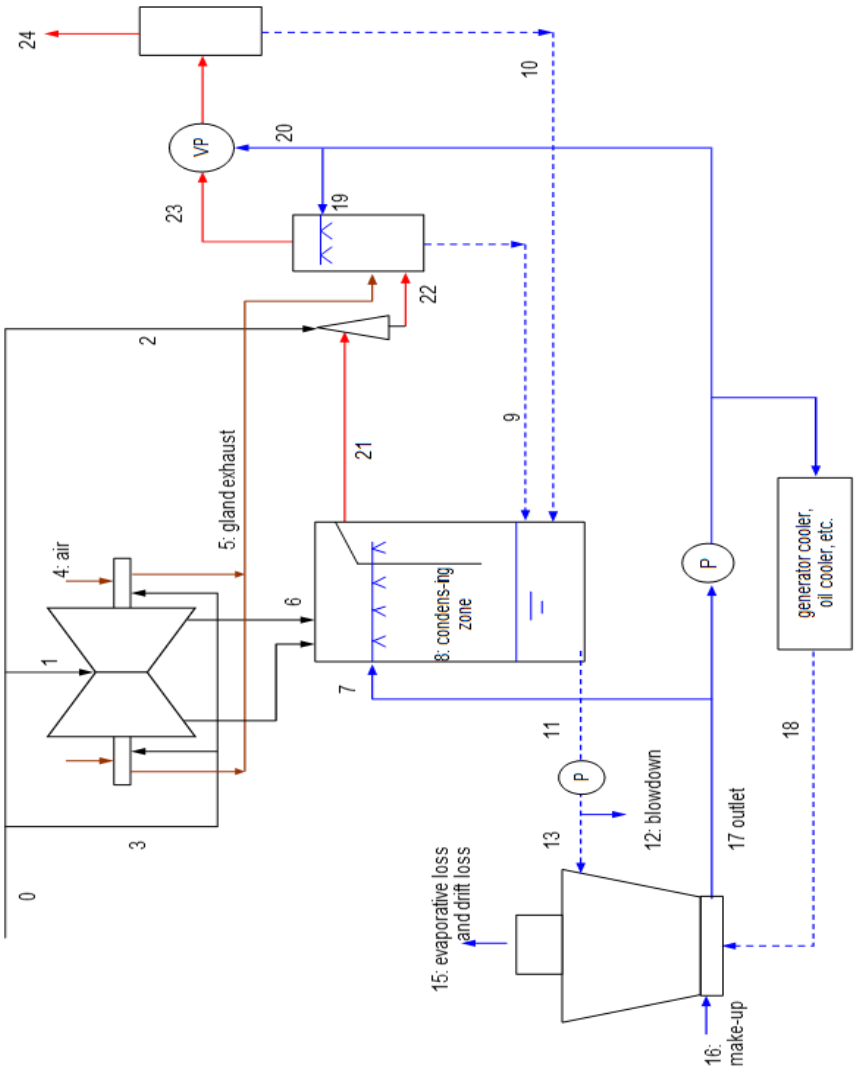
2. Preliminary plant performance

Based on the aforementioned process flow and design parameters, a preliminary heat and mass balance is assessed as shown in Figure 3.3-12.

In order to attain a net output of 76 MW per unit, tentative plant performance will be as follows:

Required steam flow	482.5 t/h
Generator output	80.3 MW
Parasitic load	4.2 MW
(house load + main transformer loss)	
Net output	76.14 MW

Point	Pressure [kPa]	Temp. [C]	Vapor/Water [t/h]	Vapor/Water [kg/s]	NCG [t/h]	NCG [kg/s]
0	900.0	175.2	477.6	132.7	4.8	1.3
1	900.0	175.2	471.4	131.0	4.8	1.3
2	900.0	175.2	5.5	1.5	0.1	0.0
3	900.0	175.2	0.7	0.2	0.0	0.0
5	26.0		0.4	0.1	0.0	0.0
6	7.5	40.3	471.7	131.0	4.8	1.3
7	80.0	23.1	16,039.2	4,455.3		
8Vap	7.5	40.3	471.7	131.0	4.8	1.3
8Liq	7.5	37.1	16,509.1	4,585.9		
9	26.0	41.7	247.6	68.8		
10	90.0	34.8	29.0	8.1		
11	7.5	37.1	16,785.7	4,662.7		
12	308.4	37.1	118.5	32.9		
13	308.4	37.1	16,667.3	4,629.8		
15			359.0	99.7		
16		20.0	0.0	0.0		
17	80.0	23.1	16,776.3	4,660.1		
18	100.0	28.1	468.0	130.0		
19	354.7	23.1	240.3	66.8		
20	354.7	23.1	28.8	8.0		
21	7.5	26.1	1.8	0.5	4.8	1.3
22	26.0		7.3	2.0	4.8	1.3
23	26.0	28.1	0.4	0.1	4.8	1.3
24	90.0	34.3	0.1	0.0	4.8	1.3



Generator output = 80,304 kW
Parasitic load + Main transformer loss = 4,160 kW
Net output = 76,144 kW

Plant steam consuption = 482.4 t/h
Condensate blowdown = 118.5 t/h

Steam pressure = 9.00 bar (abs)
Design wet-bulb temperature = 18 deg C

(Source: Olkaria VII F.S. Report)

Figure 3.3-12 Heat and Mass Balance Diagram (for Reference)

3. Mechanical Equipment

a. Steam Turbine

The steam turbine used for this Project shall be designed and proven for geothermal applications. The assumed turbine type for Olkaria V Additional Unit is the same as those of Olkaria IV, IAU and V existing units.

Main specifications of the turbine:

Type Double-flow, condensing, downward exhaust.

Rated output 80.3 MW (gross)

No. of units 1

Steam conditions 9 bar (abs), 175.2 °C

Speed 3,000 rpm

Ancillary equipment:

Turbine control system 1 set/unit

Turbine protection system 1 set/unit

Lube oil unit 1 set/unit

Gland seal system 1 set/unit

b. Main Steam System

i. Scrubber

In order to prevent the inflow of mist or drain water into the turbine, a cyclone type scrubber will be installed in the main steam piping for each unit.

ii. Steam Flow Meter

For control and monitoring of plant operation, a steam flow meter will be installed downstream of the mist eliminator or scrubber so that the effect of scale buildup on its accuracy will be minimal.

iii. Main Stop Valve and Control Valve

The turbine inlet steam pipe splits into two branches, and both will be connected to the turbine through main stop valves (MSVs) and control valves (CVs). This arrangement will allow daily steam-free testing during turbine operation and prevent the sticking of these valves due to scale deposition.

c. Main Condenser

The condenser type is assumed to be of the direct-contact type, which is of low cost and having good cooling efficiency, similar to those of the existing units of Olkaria V. The steam, after driving the turbine, enters the condenser where is cooled by direct contact with sprinkled cooled water turning into condensed hot liquid.

d. Gas Extraction System

The gas extraction system will be a hybrid system similar to that of Olkaria V generation Unit 1 and Unit 2. The hybrid system consists of steam jet ejectors, inter-condensers, liquid ring vacuum pumps and seal water separators, back-up ejectors and after-condensers for the vacuum pump. The gas extraction system is recommended to have a capacity to handle 1 % in weight of NCG contents in steam, taking into account the expected NCG contents (0.5%wt) and the possibility of significant fluctuations. The number of the ejectors (one or two stages) will depend on the detailed design of the EPC contractor.

e. Pumps

The hotwell pumps transfer the mixture of condensate and cooling water from the condenser's hotwell to the cooling tower. The auxiliary cooling water pumps supply cooling water to the oil cooler, generator cooler, gas extraction system, air compressor, etc. The condensate pump transfers the surplus of the mixture of condensate and cooling water to a reinjection well dedicated to condensate.

f. Cooling Tower

The cooling tower is assumed will be of the forced draft counter-flow wet cooling tower type, the same type of the existing plant. The structure is assumed of FRP and with eight cells. Stairs and a lifting device will be provided for maintenance work. A wire mesh screen will be installed at the outlet of the cooling tower basin to prevent dust and other particles from entering the cooling water system equipment. Low-noise fans will be installed in the cooling tower as noise countermeasure.

4. Electrical Equipment

a. General

The plant's single-line diagram is shown in Figure 3.3-13. The 11 kV generated power is stepped up to 220 kV by the generator transformer and transmitted to Olkaria I AU substation. Meanwhile, the station power of 3.3kV and 415V is supplied by the unit main transformer and the Auxiliary transformer.

Circuit breakers (CB) in the main circuit are located as follows.

- Generator CB: at the Outlet of the generator
- Generator Transformer CB: on the High-voltage side of the Main transformer
- Unit transformer CB: on the Low-voltage side of the Unit transformer

All breakers are equipped with a local/remote control switching function, allowing control at the local side and remote control from the DCS installed in the central control room.

b. Generator

An air-cooled, three-phase synchronous generator planned to be installed for power station. This typed generator is easy to operate, requires less maintenance and is well-proven in geothermal environments. Corrosive gas like H_2S will be removed from the cooling air for the generator by utilizing oxidized catalytic filters etc., since the atmosphere around the geothermal field contains highly corrosive H_2S gas. The exciter system planned to be adopted brushless type, which has less mechanical contact part.

Specifications of the generator are as follows.

Type:	Cylindrical revolving-field rotor type, enclosed air-cooled, three-phase synchronous generator
Rated Output:	94.47 MVA
Rated Voltage:	11 kV
Frequency:	50 Hz
Speed:	3,000rpm
Power Factor:	0.85(lag) to 0.95(lead)
Neutral grounding:	Grounding with transformer
Excitation System	Brush less type

c. Motors for Auxiliary Equipment

Motors installed to drive pumps, fans, and other auxiliary equipment in the power plant should have a capacity of at least 115% of the required power, which is a design requirement to exceeds the plant design life.

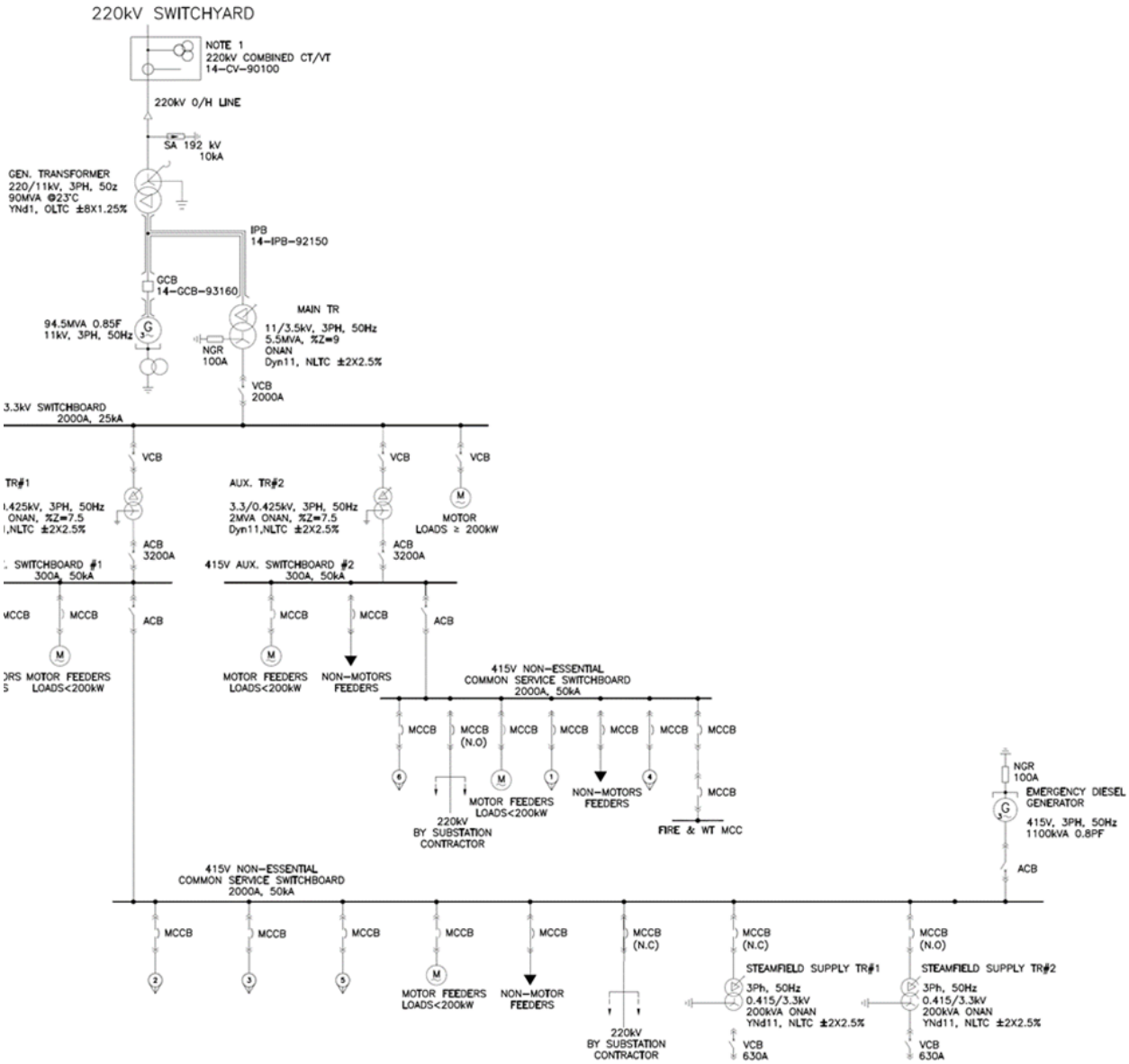
The required specifications for auxiliary equipment motors are as follows:

Type	High efficiency type
Protection degree	IP55 TEFC (IP65 for earth terminal box)
Insulation class	Class F
Temperature rise limit	Class B
Design power factor	0.85 or more
Applicable standards	IEC 60034 and IEC60072
Starting method	Direct online starting (Full voltage and 80% voltage)
Starting current limit	6 times or less
Starting requirements	✓ Cold start 3 times or more per hour ✓ Hot start 2 times per hour
Winding temperature monitoring	✓ 5 kW to less than 50 kW: Electronic protection relay monitoring (thermistor type) ✓ 200 kW or more: Temperature sensor (with monitoring from DCS)
Others	✓ Exposed copper shall be tin plated and wiring terminations also be tinned. ✓ All fixing materials such as screw nuts, bolts, etc. shall be of SUS 316 to prevent sulphide corrosion.

d. Emergency Generator

In consideration of a power outage occurrences, an emergency diesel generator is planned to be installed so that the safely shutdown of power plant. The emergency generator shall have an automatic start function to automatically supply power to the plant equipment after a power outage is detected within the plant. The generator is planned to have a capacity of 110% of the total power required for plant essential equipment and plant restart.

The emergency generator system shall include equipment such as main engine ventilation and air conditioning equipment, lighting, space heaters, start-up battery system, circuit breakers, lubricating oil pumps, and starting air compressor.



(Source: Olkaria VII F.S. Report)

Figure 3.3-13 Power Plat Single Line Diagram (for Reference)

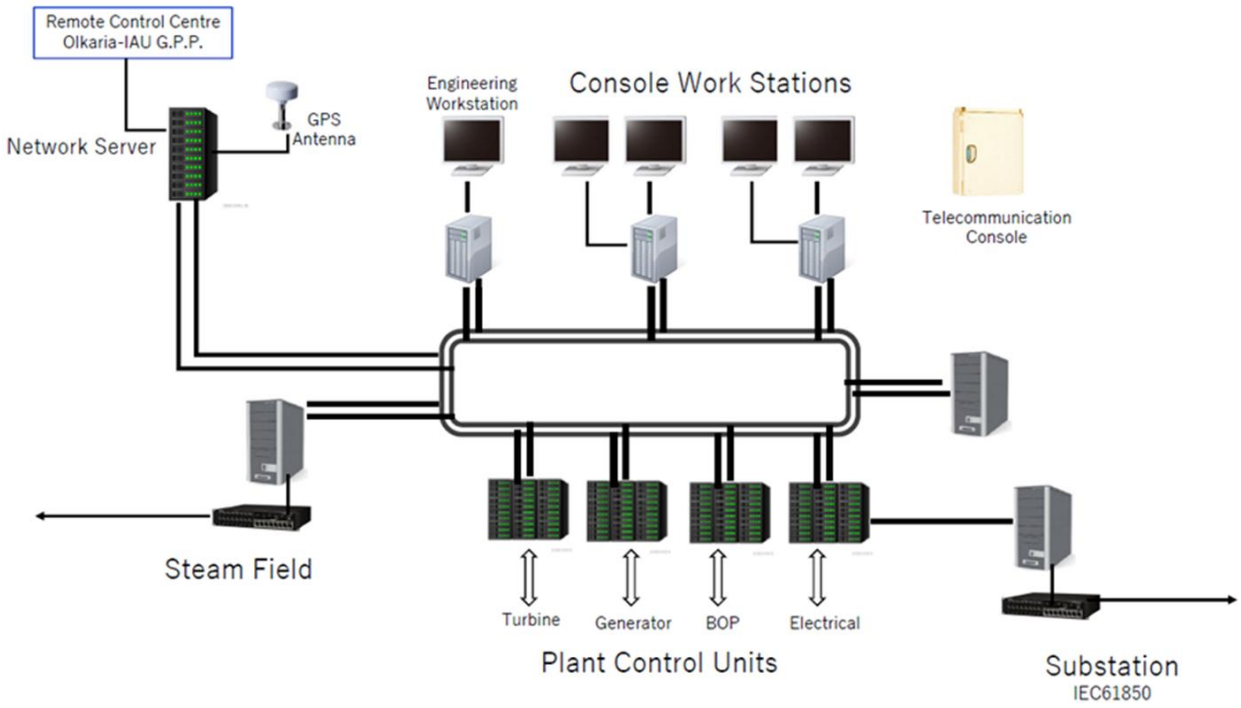
5. Instrumentation and Control System

The automatic acquisition and archiving of various data of the facility is important for effective management of the power plant. To accomplish this goal, a microprocessor-based Distributed Control System (DCS) will be installed. This DCS system contributes to guarantee the fail-safe operation of the plant with high reliability and productivity. Figure 3.3-14 shows the plant control system including DCS.

The DCS consists of a plant control and instrumentation system and LCD to interface with the operator. The operation of the plant can be controlled from LCD/keyboard in the Control Room, which are the interface between the DCS and operators. A plant interlock system will be provided in addition to the control system. The interlock system for equipment operation will be included in the DCS, while, for higher reliability, digital relays with hard-wired circuit will be responsible for protection of the generator and the steam turbine.

The main control function and device in geothermal power plants are as follows.

- Turbine protection and control (turbine governor control)
- Generator and transformer protection and control (including voltage regulating function by AVR)
- Common electrical equipment control and protection (medium-voltage and low-voltage switchgears and substation interface panels, etc.)
- BOP facilities (water treatment, etc.) control and protection
- DATA transmission equipment (telecom system, SCADA system)
- DCS server
- Steam-field (SAGS) Control interface panel (SCIP)
- Human machine interface (HMI)
- Operator workstation (with LCD and keyboard)
- Engineering workstation (with LCD and keyboard)
- Plant data measurement function
- Steam-field (SAGS) monitoring. Including remote operation of control valves of wells and separator station



(source: Olkaria VII F.S. Report)

Figure 3.3-14 Plant control system (for Reference)

6. Plant Communication System

The Plant DCS shall provide an integrated system for the control, monitoring, protection, alarming and plant management from the plant control room through the plant communication system.

The Plant communication system shall consist of following equipment

- Redundant data communication network for plant control
- Redundant microprocessors for control and monitoring functions
- Redundant CPU controllers with power supply units
- Data server

7. Plant main control system and local control functions

The system will have the following main control functions for operating the geothermal power plant:

a. Automatic Turbine and Generator Controller

This controller can control the following:

- Automatic start-up and shutdown of the turbine (from turbine start-up at cold condition to 100 % load and vice versa).
- Automatic start-up of the turbine and load regulation in conjunction with a digital electric – hydraulic governor.

b. Condenser level.

The hotwell pumps feed the cooling towers with the condensate leaving the condenser. The water level transmitters mounted in the condenser transmit signals representative of condensate levels to the DCS. The specific control logic will be programmed within the DCS for it to control the condensate level in the condenser in order to protect the hotwell pumps and the steam turbine. As a backup protection, level switches are installed to activate alarms should the condenser level become high or low, and/or, to shut down the unit in case the condenser level becomes excessively high or excessively low. This protection function will also be included in the DCS.

c. Cooling Tower Level

In order to regulate cooling tower basin level, the flow of the cooling water from the cooling tower and the flow of the condensate to the cooling tower are controlled by control valves.

d. Emergency Generator

An emergency diesel generator is installed in order to supply emergency power for safe shutdown of the power plant. The DCS also monitors the operating status of the emergency diesel generator.

e. Communication System

An optical fibre communication system and a Power Line Carrier system will be installed for communication between KPLC, major substations, and the power plant. A Supervisory Control and Data Acquisition (SCADA) system collects various data about the power plant system, and periodically sends designated data to KPLC and the Remote-Control Centre Room in Olkaria I Units 4 and 5

8. Measures against corrosion

The geothermal steam and the ambient air of a geothermal field commonly contain a small amounts of corrosive gases such as hydrogen sulphide. Thus, it is essential to consider corrosion control measures, for example:

- The design and manufacturing of the turbine should consider the selection of materials suitable to resist corrosion and erosion resulting from the nature of the geothermal steam in use.
- Oxidation catalyst filters should be installed at air intakes of the generator and generator room in order to remove hydrogen sulphide from the air.
- The air conditioning system of the control room and of the electrical rooms should be equipped with hydrogen sulphide gas removal filters.
- The cold-water basin (and the super structure if applicable) should be constructed with sulphate resistant cement and anti-corrosive coating,
- Pipe thickness should include sufficient corrosion allowance.
- Material and finishing should be resistant to corrosive atmospheres. Apply corrosion control design as necessary and using stainless steel, FRP, anti-corrosive coating, tight sealing, etc.
- For equipment installed outdoors, enough spare parts should be procured and stored.

3.3.2. Review of Drilling Plan

The latest well drilling plan for the Olkaria V additional unit Project is summarised in Table 3.3-4 with reference to the Olkaria VII Feasibility Study Report. Before start of commercial operation, one new cold condensate reinjection well is planned to be drilled in 2027.

Following, the commercial operation will be commenced from 2028 with the existing 18 production wells, 7 hot brine reinjection wells, and 1 new cold condensate reinjection well. After commencement of the commercial operation, 7 make-up production wells are planned to be drilled sequentially in years 2033, 2037, 2040, 2042, 2045, 2047, and 2050. This plan is aligned with the requirement of steam flow rate to generate 80.3 MW gross of power output for 25 years and keeping yet an adequate margin (6%) of steam supply, which is described in Section 3.2.

Table 3.3-4 Geothermal Resource Development Plan

Year	Drilling description	Year	Drilling description
2027	Cold Condensate Reinjection Well	2040	Make-up Production Well
2028	(expected COD)	2041	
2029		2042	Make-up Production Well
2030		2043	
2031		2044	
2032		2045	Make-up Production Well
2033	Make-up Production Well	2046	
2034		2047	Make-up Production Well
2035		2048	
2036		2049	
2037	Make-up Production Well	2050	Make-up Production Well
2038		2051	
2039		2052	

(Source: Study Team based on KenGen Data)

Within the above plan, the make-up production wells will be allocated to the well pad from the viewpoint of SAGS design. Although the importance of the capacity of surface system is well understood, the resource potential of the reservoir shall be confirmed by interference production tests and numerical

simulation at least and prior to the drilling of make-up production wells. The Study Team recommends implementing periodical numerical simulations with updated models which contributes to optimize the well drilling plan and improve the reservoir management plan.

3.3.3. Review of Steamfield facilities

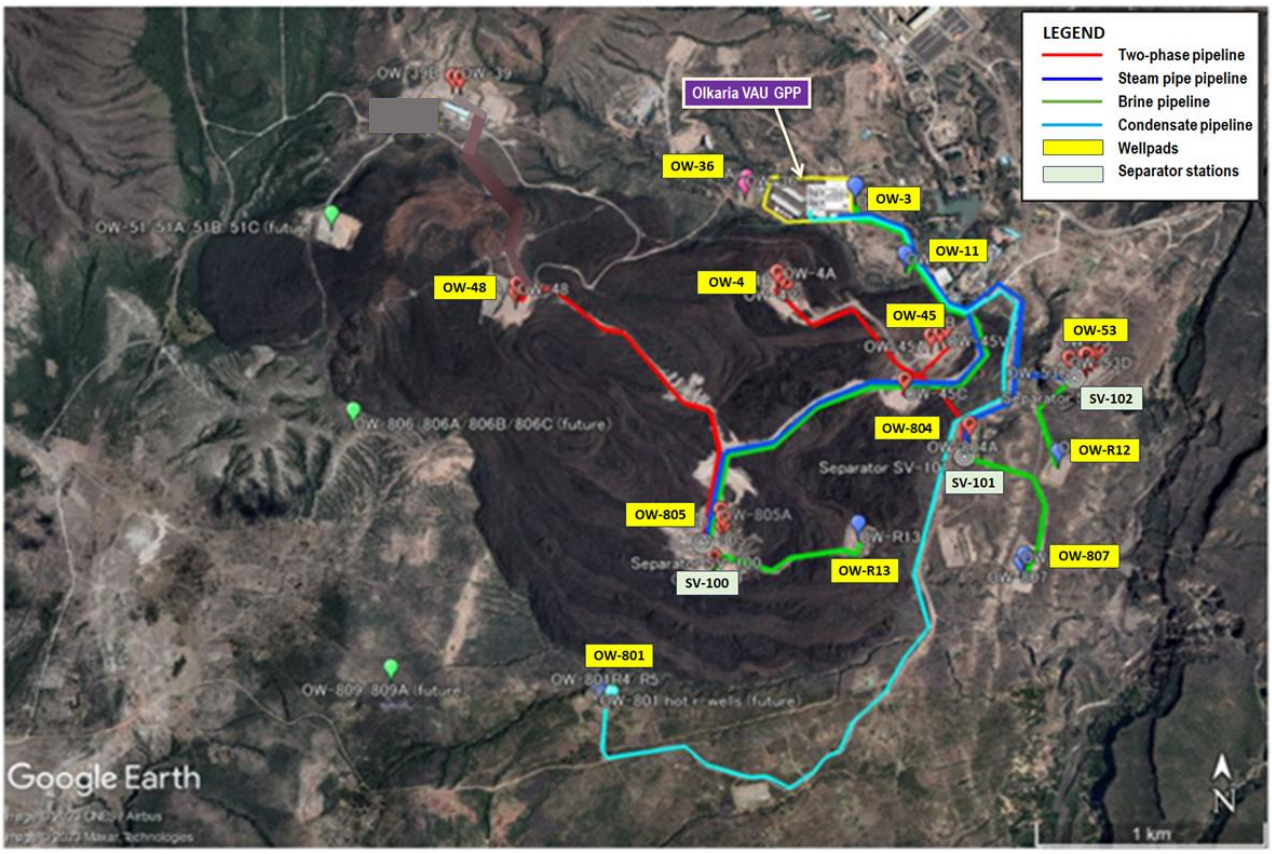
(1) Configuration of the Steamfield

The group of wells assigned for Project include eighteen (18) production wells, seven (7) hot brine reinjection wells and, in addition, a condensate reinjection well located in or near well pad OW-801.

The proposed conceptual design of the Steamfield Above Ground System (SAGS) foresees the construction of three separation stations for which the most plausible locations were determined considering the relative location and elevation of the production and reinjection wells (Figure 3.3-15).

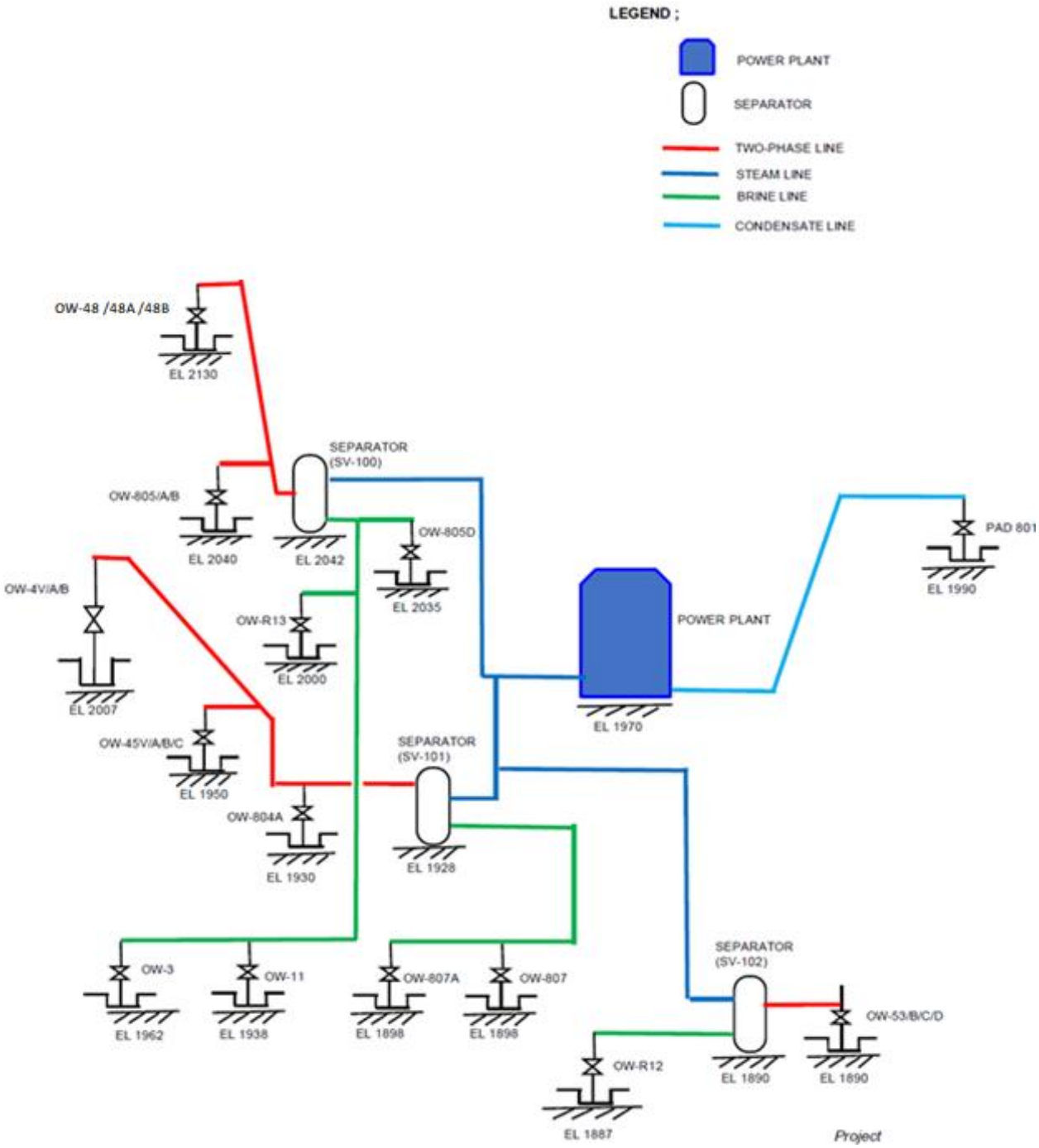
Likewise, data on pipe corridors and pipe routes including the elevation profile of the study area were gathered for the preparation of the SAGS conceptual design. The condensate generated within the power plant will be conveyed through a pumping system from the cooling tower basin and transported to a condensate reinjection well. A dedicated steam vent station was designed and constructed approximately at 600 meters from the power plant; alternatively, it may also be located at the south-west corner of the plant site.

Given the spatial arrangement of the production well pads, each separated by roughly a kilometre and positioned at varying elevations, the most feasible technical approach entails grouping the 18 production wells into three (3) clusters, with each cluster connected to a singular separator system (Figure 3.3-16). This configuration capitalizes on the lower elevation of the designated reinjection wells: OW-R13, OW-807, OW-807A, OW-R12, OW-03, OW-11 and OW-805D, facilitating gravity-based reinjection



(Source: Olkaria VII F.S. Report)

Figure 3.3-15 Proposed SAGS layout



(Source: Olkaria VII F.S. Report, modified by Study Team)

Figure 3.3-16 SAGS elevation profile

(2) Main components of the Steamfield

(a) Two-phase Lines

All two-phase lines have been configured to facilitate downhill flow, thereby avoiding the occurrence of slug flow.

- Cluster 1: The two-phase fluid from well pads OW-48 and OW-805 converge into a primary two-phase header that is subsequently connected to the separator stationed SV-100 within well pad OW-805.
- Cluster 2: The pad two-phase fluid from pads OW-4 and OW-45 and OW-804 combine into a unified main two-phase header and then connected to the separator station SV-101 in pad OW-804.
- Cluster 3: The two-phase pipe is directly connected to the separator SV-102 located in well pad OW-53.

(b) Separator Stations

The separator stations will be positioned at the well pad of lowest elevation within the group of interconnected well pads. The chosen separators for this Project are vertical cyclone separators.

Each separator is fitted with a level control valve (LCV) to regulate the separator's level and manage the discharge of separated brine into the brine reinjection line. In addition to the LCV, a motorized emergency dump valve is integrated, facilitating the emergency release of brine when the separator reaches a high-high level. This emergency dump valve is linked to either a silencer or an Atmospheric Flash Tank (AFT). The brine discharged from the AFT is directed to a water pond, designed to capture the released brine.

The steam line downstream of the separator is provided with Pressure Safety Valves (PSV) which serve as the relief element in case of overpressure.

(c) Steam Lines

The steam from the three separators stations is conveyed through cross-country steam pipelines, ultimately entering a 42” diameter steam header leading to the power plant station's inlet. A scrubber vessel is situated at the end of the 42” diameter header. This vessel functions as the final stage for steam processing, ensuring the elimination of any condensate and the supply of high-quality steam. This purified steam then progresses into the power plant's steam turbine.

(d) Brine Lines

The brine separated from the two-phase flow by each individual separator at the Separation Stations is separately reinjected via gravity into hot brine reinjection wells: OW-807, OW-807A, OW-805D, OW-R12, OW-03 and OW-11 and, OW-R13.

In order to confirm the reinjection capacity of OW-805D, OW-3 and OW-11, it is highly recommended to carry out reinjection capacity tests of each well. Once the total injection capacity had been confirmed, it is required to reconsider the optimum redundancy in comparison with the total volume of brine produced.

The separators are positioned at higher level compared to the reinjection pads and allowing for natural gravitational flow of the separated brine for injection. A solids trap shall be provided at each branched line to capture sand, drill cuttings or debris being dragged by the brine before its reinjection.

It is also advisable to consider installing a backflow protection set-up to protect the brine line in case any reinjection well develops abnormal pressure signalling potential backflow. Immediate steam field shutdown shall be foreseen to have to be implemented in the event of reinjection well backflow.

(e) Condensate Management

In regard cold condensate management, the condensate generated within the power plant will be conveyed through a pumping system from the cooling tower basin and transported to the cold condensate reinjection well OW-801 or other drilled nearby. The well pad of OW-801 is located approximately 5 km away from the power station.

All other effluents and condensate flows collected in the thermal ponds available at well pads will be transferred to the thermal pond of pad OW-53. The collected volume will be later pumped into the main condensate line going to well pad OW-801.

(3) Pipe sizes

Pipe sizes were optimized by pressure drop calculations using a hydraulic model of the SAGS based on the process flow diagram (Figure 3.3-17) and the piping route (Figure 3.3-15) all in compliance with the following design parameters:

(a) Two-phase Lines

There should be no slug flow occurrence along the pipeline and, the total pressure loss should not be higher than 2 bars.

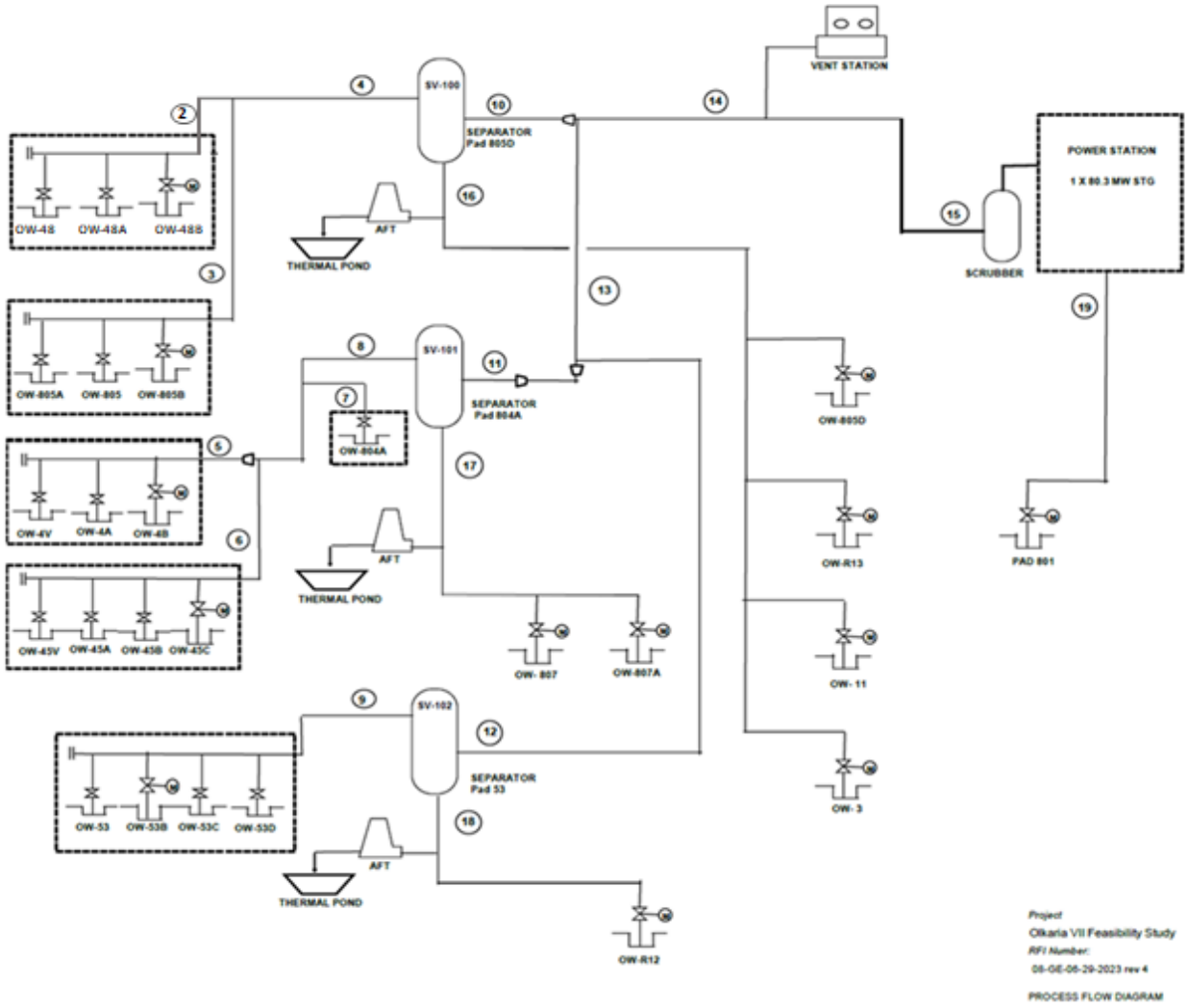
(b) Steam Lines

The first 300 meters steam pipeline from the separator should flow at a velocity lower or equal to the scrubbing velocity limit of 27 meters/sec.

Steam velocity in cross-country lines should not exceed 60 meters/s with total pressure loss not higher than 2 bars. The 60 m/s maximum steam velocity is the limit for erosional velocity derived from the API RP14E empirical formula for erosional velocity for saturated steam.

(c) Brine Lines

To prevent the brine from flashing (boiling) inside the pipeline, the brine pressure should not drop below the separator pressure.



STREAM NUMBER		1	2	3	4	5	6	7	8	9	10	11	12
DESCRIPTION			TWO PHASE	TWO PHASE	TWO PHASE	TWO PHASE	TWO PHASE	TWO PHASE	TWO PHASE	TWO PHASE	STEAM	STEAM	STEAM
FLOW	t/h		216	392	608	249	289	46	584	216	203	272	115
ENTHALPHY	kJ/kg		1719	1295	1446	1539	1837	1856	1711	1842	2780	2780	2779
FLUID PRESSURE	bar-A		11.6	11.2	11	12.5	12	11.1	11.1	11.07	10.8	10.7	10.5
FLUID TEMPERATURE	deg C		186	185	183	189	188	185	184	182	183	183	182
PIPE DIAMETER	mm		600	600	750	600	600	350	750	600	750	900	600

STREAM NUMBER		13	14	15	16	17	18	19					
DESCRIPTION		STEAM	STEAM	STEAM	BRINE	BRINE	BRINE	CONDENSATE					
FLOW	t/h	388	591	591	405	312	101	118.5					
ENTHALPHY	kJ/kg	2778	2776	2774	776	776	772	167					
FLUID PRESSURE	bar-A	10.3	9.8	9	10.8	10.7	10.5	ATM					
FLUID TEMPERATURE	deg C	181	179	177	184	184	182	40					
PIPE DIAMETER	mm	900	1050	1050	350	250	250	200					

(Source: Olkaria VII F.S. Report, modified by Study Team)

Figure 3.3-17 SAGS flow diagram

3.3.4. Review of Transmission Line and Switchyard Plan

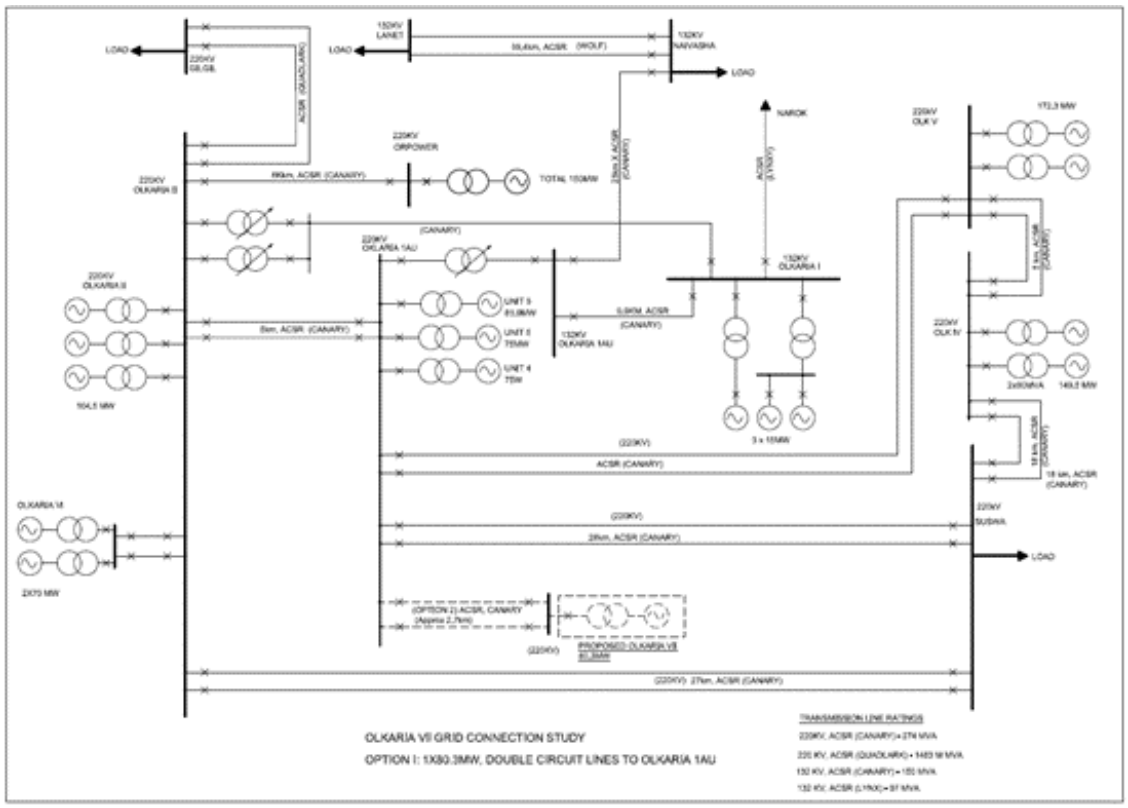
A) Transmission Line Study

(1) Power evacuation options

The three (3) grid connection options that were considered for power evacuation from the Olkaria-VII GPP in the Feasibility Study are the followings:

Option I: Connection to the Olkaria-IAU power plant 220/132 kV substation.

This option assumes the power plant will be connected to the Olkaria IAU through the construction of an approximately 2.7km double circuit 220 kV transmission line in canary conductor. Refer to Figure 3.3-18



(Source: Olkaria VII F.S. Report)

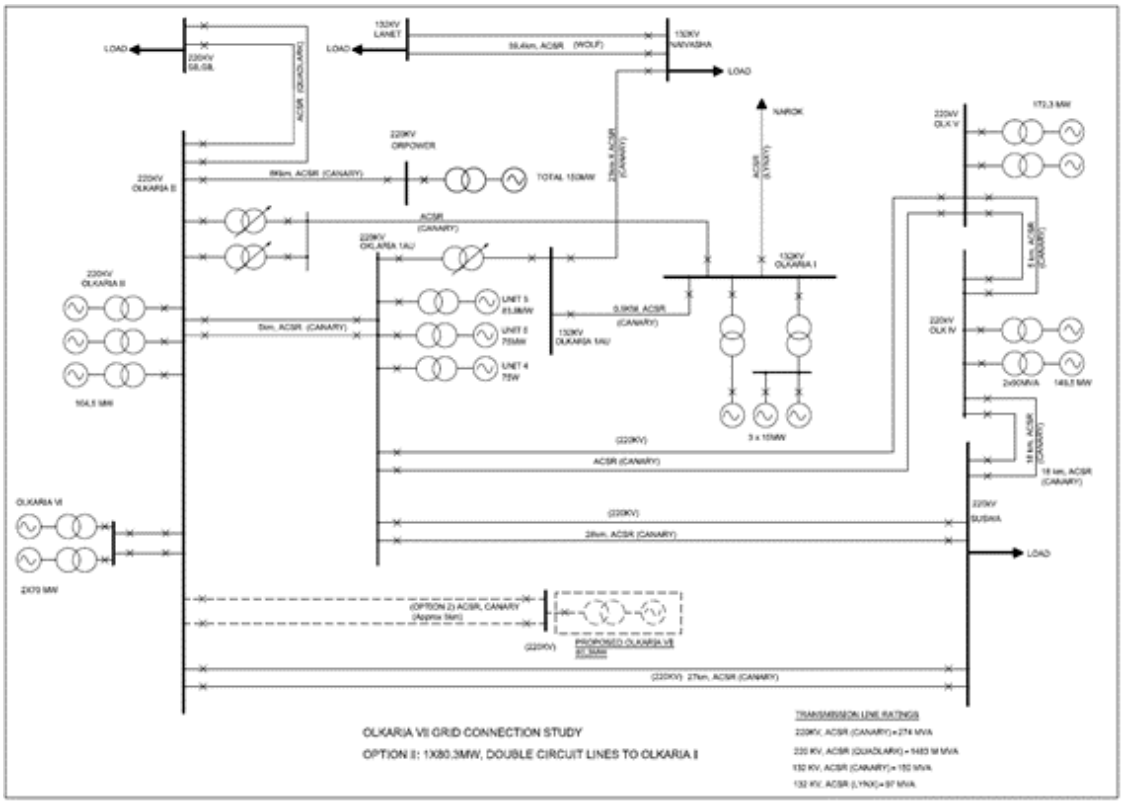
Figure 3.3-18 Connection to the Olkaria-IAU power plant substation

Option II: Connection to the Olkaria-II 220kV substation.

The new power plant could be connected to the Olkaria II 220 kV switchyard through the construction of approximately 6km 220kV double circuit line in canary conductor. Refer to Figure 3.3-19.

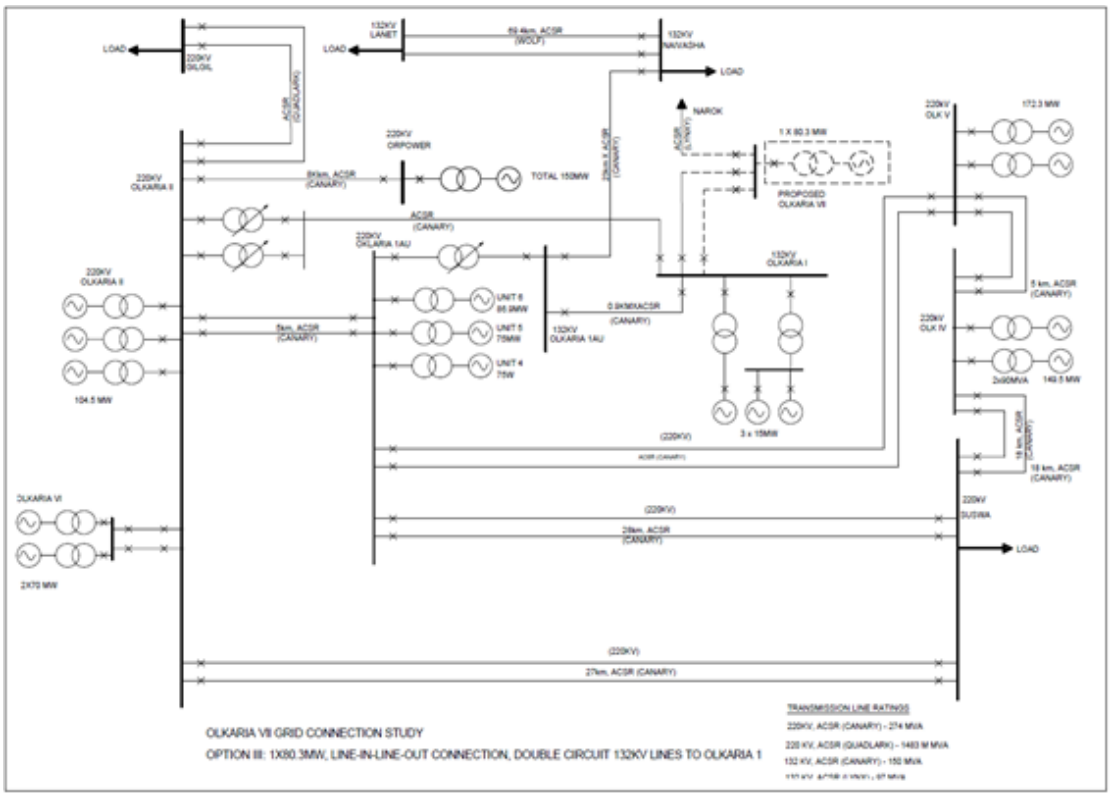
Option III: Connection to the Olkaria-I –Narok 132 kV Transmission Line.

This option could be implemented through a loop–in-loop out of the existing Olkaria I - Narok 132kV transmission line into the Olkaria-VII GPP. In addition, stringing of the second 132kV line to complete the Olkaria-VAU to Olkaria-I 132kV double circuit line. Refer to Figure 3.3-20.



(Source: Olkaria VII F.S. Report)

Figure 3.3-19 Connection to the Olkaria- II 220kV substation



(Source: Olkaria VII F.S. Report)

Figure 3.3-20 Connection to the Olkaria-I –Narok 132 kV Transmission Line

(2) Summary of key Transmission Line loadings

Table 3.3-5 below indicates a summary of the expected loading in key transmission lines through the Olkaria region for the 2028 at System Peak Load conditions and relevant with the three options for power evacuation described in above (1).

Table 3.3-5 Peak loading on system key Transmission Lines

Transmission Line	Option I		Option II		Option III	
	MVA	%	MVA	%	MVA	%
Olkaria-II –Suswa 220kV	104.0	37.2	106.3	37.9	103.5	36.8
Olkaria-II – Gilgil 220 kV	92.9	10.1	93.2	10.1	91.0	9.9
Olkaria-IAU –Suswa 220kV	128.4	46.0	126.5	45.0	124.7	44.3
Olkaria-IV –Suswa 220kV	154.2	55.1	152.4	54.1	150.9	53.6
Olkaria-IAU – Olkaria-II 220kV	33.4	11.9	-29.7	10.6	28.9	10.3
Olkaria-V – Olkaria IAU	17.8	6.4	45.7	16.2	45.5	16.1
Olkaria-V – Olkaria IV	68.8	20.7	69.0	20.6	67.7	20.2
Olkaria-VI – Olkaria II	70.4	25.2	71.0	25.3	71.2	25.3
Olkaria-VAU – Olkaria II	-	-	-		-	-
Suswa-Nairobi North 220 kV	232.7	83.3	233.5	83.2	230.5	82.1
Suswa – Kimuka 400 kV	308.5	18.6	307.3	18.5	305.9	18.4
Suswa-Gilgil 400 kV	40.8	2.5	40.4	2.4	39.8	2.4
Gilgil – Thika 400 kV	169.6	10.2	167.7	10.1	167.2	10.0
Olkaria-II – Olkaria-I 132 kV	49.4	40.7	68.5	49.7	25.4	18.5
Olkaria-I – Olkaria-IAU 132 kV	84.3	43.6	84.5	43.6	120.9	62.5
Olkaria-IAU – Naivasha 132 kV	115.8	60	115.5	59.7	133.3	68.9

(Source: Olkaria VII F.S. Report)

(3) Bus Voltage Violations check

The Grid Code of April 2021, section 6.1.4.2, specifies the following operating voltage ranges:

- Normal Operating voltage range 95% to 105%: East African Power Pool (EAPP) 500 kV, 400 kV, 230 kV, 220 kV, 132 kV, 110 kV and 66 kV.
- One grid system fault operating voltage: 90% to 110%.
- Operating voltage during multiple accidents: 85% to 120%.

The Power flow analysis of the transmission system in the Olkaria region showed that it does not deviate from the voltage fluctuation values set by the Kenyan Grid Code.

Table 3.3-6 in next page shows the results of power flow studies by PSSE under system peak and off-peak conditions.

Table 3.3-6 Peak loading on system key Transmission Lines

	Recorded Voltage Violations	
status	Buses with voltage greater than 1.0500:	Buses with voltage of less than 0.9500:
System Peak		
Option I	None	None
Option II	None	None
Option III	None	None
System Off -Peak		
Option I	None	None
Option II	None	None
Option III	None	None

(Source: Olkaria VII F.S. Report)

(4) Summary of Olkaria region system bus voltages

Table 3.3-7 shows the summary of Bus voltages of key systems throughout the Olkaria region at system peak load and relevant the three options for power evacuation.

Table 3.3-7 Voltage violations under Peak Conditions

Bus	**Option I**		**Option II**		**Option III**	
	Voltage (kV)	P.U	Voltage (kV)	P.U	Voltage (kV)	P.U
Olkaria-II 220 kV	224.3	1.02	225.4	1.02	225.6	1.03
Olkaria-IAU 220 kV	224.4	1.02	225.0	1.02	225.7	1.03
Olkaria-III 220 kV	224.3	1.02	225.3	1.02	225.4	1.02
Olkaria-IV 220 kV	224.6	1.02	226.1	1.03	226.3	1.03
Olkaria-V 220 kV	224.6	1.02	226.3	1.03	226.4	1.03
Olkaria-VI 220 kV	224.3	1.02	225.4	1.02	225.6	1.03
Olkaria-VAU 220 kV	224.4	1.02	225.4	1.02		
Suswa 220 kV	224.2	1.02	225.2	1.02	225.4	1.02
Gilgil 220 kV	223.7	1.02	224.4	1.02	224.5	1.02
Nairobi North 220 kV	222.3	1.01	222.9	1.01	223.2	1.01
Suswa 400 kV	405.3	1.01	406.3	1.02	406.5	1.02
Gilgil 400 kV	406.3	1.02	407.1	1.02	407.2	1.02
Olkaria-I 132 kV	134.2	1.02	134.5	1.02	134.5	1.02
Olkaria-IAU 132 kV	134.2	1.02	134.4	1.02	134.5	1.02
Olkaria VAU 132 kV					134.6	1.02
Narok 132 kV	131.1	0.99	131.3	0.99	131.1	0.99
Naivasha 132 kV	132.8	1.01	132.7	1.01	132.9	1.01

(Source: Olkaria VII F.S. Report)

(5) Short Circuit Capacity calculation results

a) Methodology

Three phase short circuit fault level calculations were carried out prior and after integration of the power plant to determine its impact. All buses at existing substation have been confirmed to have enough strength against the three-phase short circuit current, as it is shown in Table 3.3-8.

Table 3.3-8 Voltage violations under Peak Conditions

Substation	Voltage (kV)	Breaker Short Circuit rating (kA)
Olkaria-II	220kV	40
Olkaria-IAU	220kV	31.5
Suswa	220kV	31.5
Olkaria-IV	220kV	31.5
Olkaria-IAU	132kV	31.5
Olkaria-I	132kV	31.5
Naivasha	132kV	25

(Source: Olkaria VII F.S. Report)

b) Short circuit capacity

Table 3.3-9 summarises the three-phase fault levels for various substations, which were calculated by PSSE under the Power Flow Study of the Olkaria-VII Feasibility Study. The results demonstrate that all transmission line circuits of the national grid in the Olkaria area grid have enough short circuit capacity against three-phase fault.

Table 3.3-9 Voltage violations under Peak Conditions

	Option I		Option II		Option III	
	MVA	Amps	MVA	Amps	MVA	Amps
Olkaria-II 220 kV	6,431.5	1,6878.4	6411.2	16825.1	6372.8	1,6724.3
Olkaria-IAU 220 kV	6,490.5	1,7033.2	6457.7	16947.2	6421.9	1,6853.2
Olkaria-III 220 kV	4,954.0	13,000.8	4948.4	12986.1	4924.9	1,2924.5
Olkaria-IV 220 kV	5,927.1	15,554.8	5899.3	15481.8	5867.7	1,5398.7
Olkaria-V 220 kV	6,049.2	15,875	6016.7	15789.8	5982.8	1,5700.7
Olkaria-VI 220 kV	6,346.3	16,654.7	6326.0	16603.9	6289.4	1,6505.4
Olkaria-VAU 220 kV	6,038.5	15,853.5	5511.3	14463.5	NA	NA
Suswa 220 kV	6,173.9	16,202.3	6154.6	16151.7	6126.9	1,6079.1
Gilgil 220 kV	4,523.8	11,871.8	4523.9	11872.2	4510.4	1,1836.7
Nairobi North 220 kV	4,004.9	10,510.1	4008.8	10520.4	3995.8	1,0486.2
Suswa 400 kV	5,788.8	8,355.4	5782.2	8346	5767.5	8,324.6
Kimuka 400 kV	5,305.6	7,657.9	5303.3	7654.7	5290.1	7,635.7
Gilgil 400 kV	5,820.9	8,401.8	5815.6	8394.1	5805.8	8,380
Olkaria-I 132 kV	2,651.6	11,597.8	2656.3	11618.3	2695.8	11,791.1
Olkaria-IAU 132 kV	2,627.2	11,491.1	2631.9	11511.6	2668.2	11,670.5
Olkaria-II 132 kV	2,603.2	11,385.6	2608.1	11407.3	2637.3	11,535.1
Olkaria-VAU 132 kV	NA	NA	NA	NA	2482.3	10,857.4
Naivasha 132 kV	2,147.9	9,394.7	2150.0	9403.6	2164.1	9465.6

(Source: Olkaria VII F.S. Report)

(6) Conclusions and Recommendations

From the comparisons made in Table 3.3-10 below, Option I should be considered the best option on the basis of lower transmission losses and better voltage stability.

Figure 3.3-21 depicts the Transmission Line route proposed for Option 1.

Table 3.3-10 Comparative summary of grid connection options

Operation condition	Option I	Option II	Option III
Transmission Line overloads	None	None	None
Highest Transmission Line loading (%)	83.3%	83.2%	82.1%
Voltage violations (within ±5%)	-1~2%	-1~2%	-1~3%
Transmission Line loss	3.06%	3.07%	3.10%

(Source: Olkaria VII F.S. Report)



(Source: Olkaria VII F.S. Report)

Figure 3.3-21 New 220kV new Transmission Line Route (Option I)

B) Sub-stations Study

a) Substation Equipment

Specifications of main equipment for modification of the Olkaria-IAU substation will be as followings:

- 220kV CB: 1600A, 40KA, SF6, Rated Voltage 245kV, USCD 43.3mm or more
- CT: 1600-800-1A, 40kA (5 core)
- CVT: 245kV, 110/√3, 110/√3

- SA: 220kV
- DS: 1600ª, 40kA, 3 pole centre break w/o ES

b) Substation Layout

Figure 3.3-22 shows the proposed layout of the 220 kV substation for Olkaria VAU power plant. Based in KenGen's comments, it will have a similar layout to the Olkaria IAU substation, including spare space for future expansion and connecting wellhead plants (existing 13MW and 20MW, and future 58MW). The planned size is 101.5m x 133m.

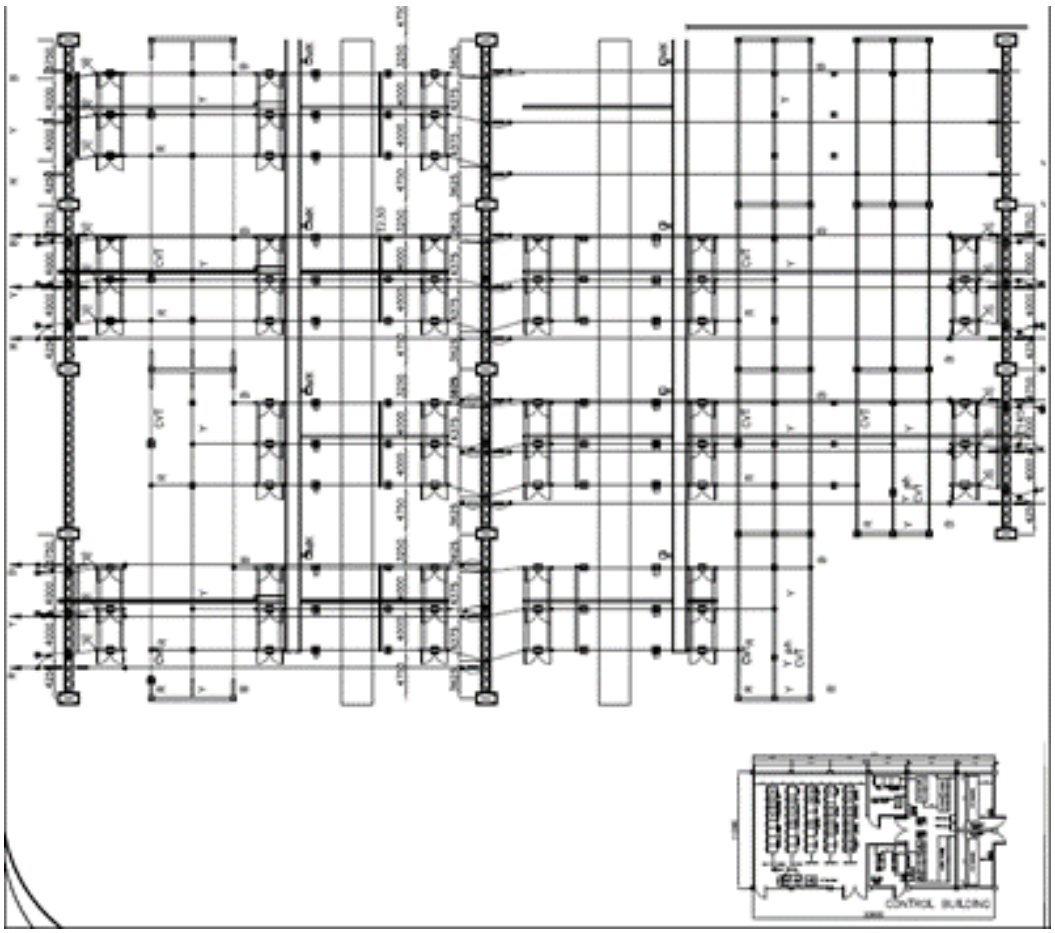
Figure 3.3-23 shows the layout of the substation of the Olkaria-IAU power plant and the enlargement work that shall be implemented on it such to receive the load from the Olkaria-VAU power plant.

Figure 3.3-24 shows the protection systems for 220kV incoming feeders from Olkaria VAU power plant.

The modifications to implement at the Olkaria-IAU substation include the addition of new two (2) bays for the incoming 220kV line with line protection system (distance relay, overcurrent protection, grounding fault relay, differential protection).

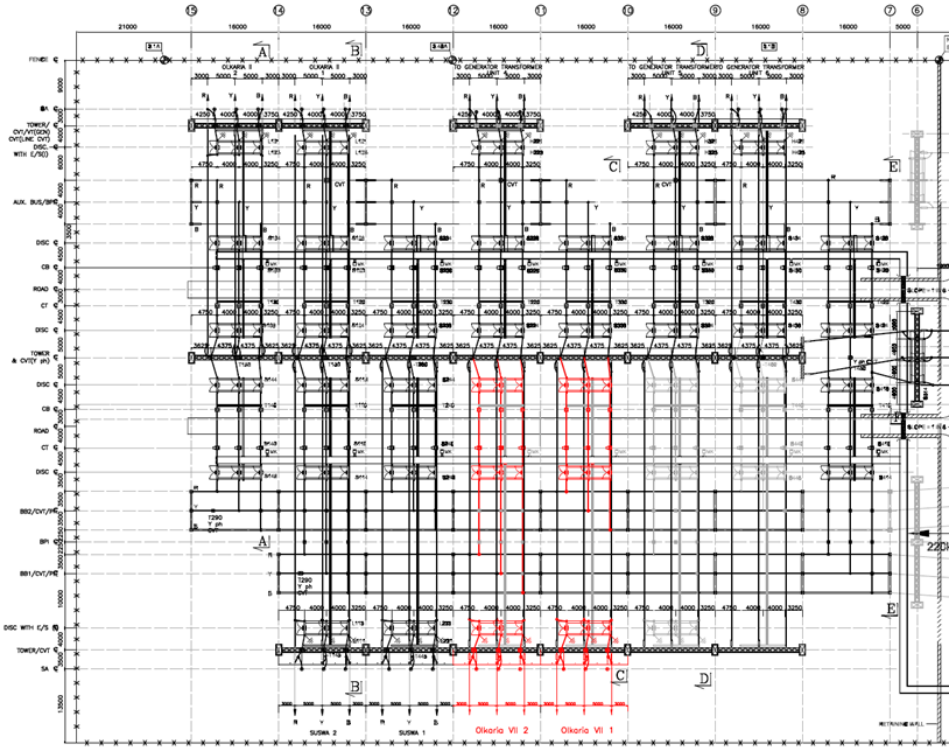
Modification and enlargement of the Control Room of the Olkaria-IAU will be implemented as depicted in red in Figure 3.3-25

The modification includes the addition of protection and operation panels for the 220kV incoming feeders for Olkaria-VAU in the control Room of the Olkaria-IAU substation.



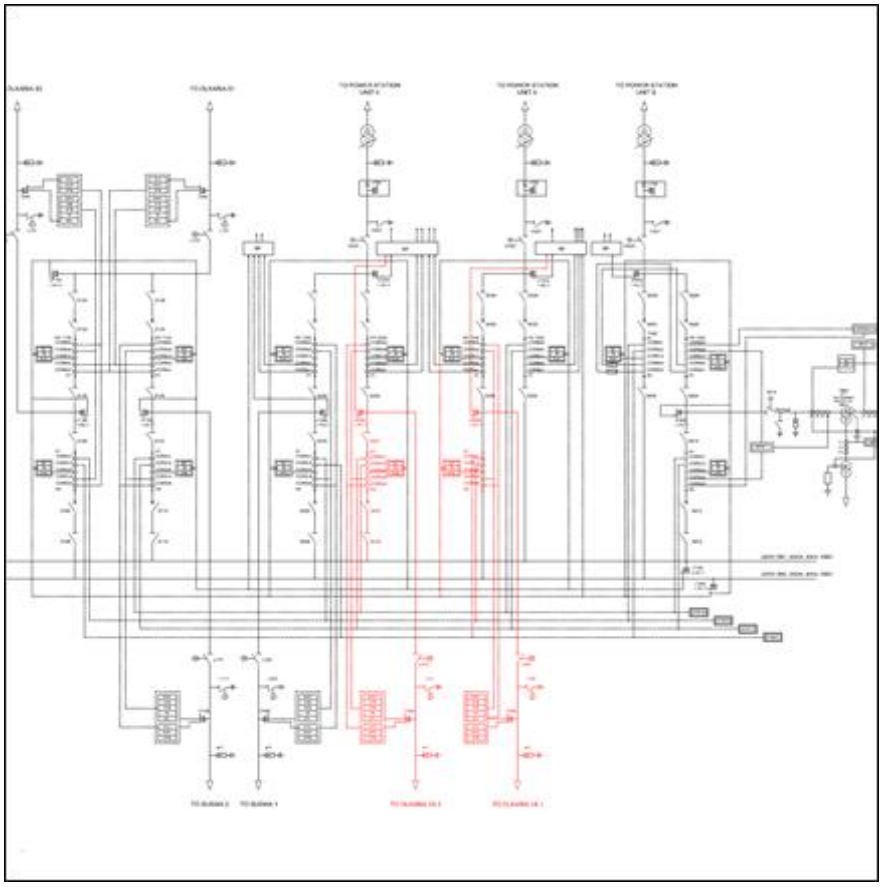
(Source: Olkaria VII F.S. Report)

Figure 3.3-22 Proposed layout of the Olkaria VAU power plant substation



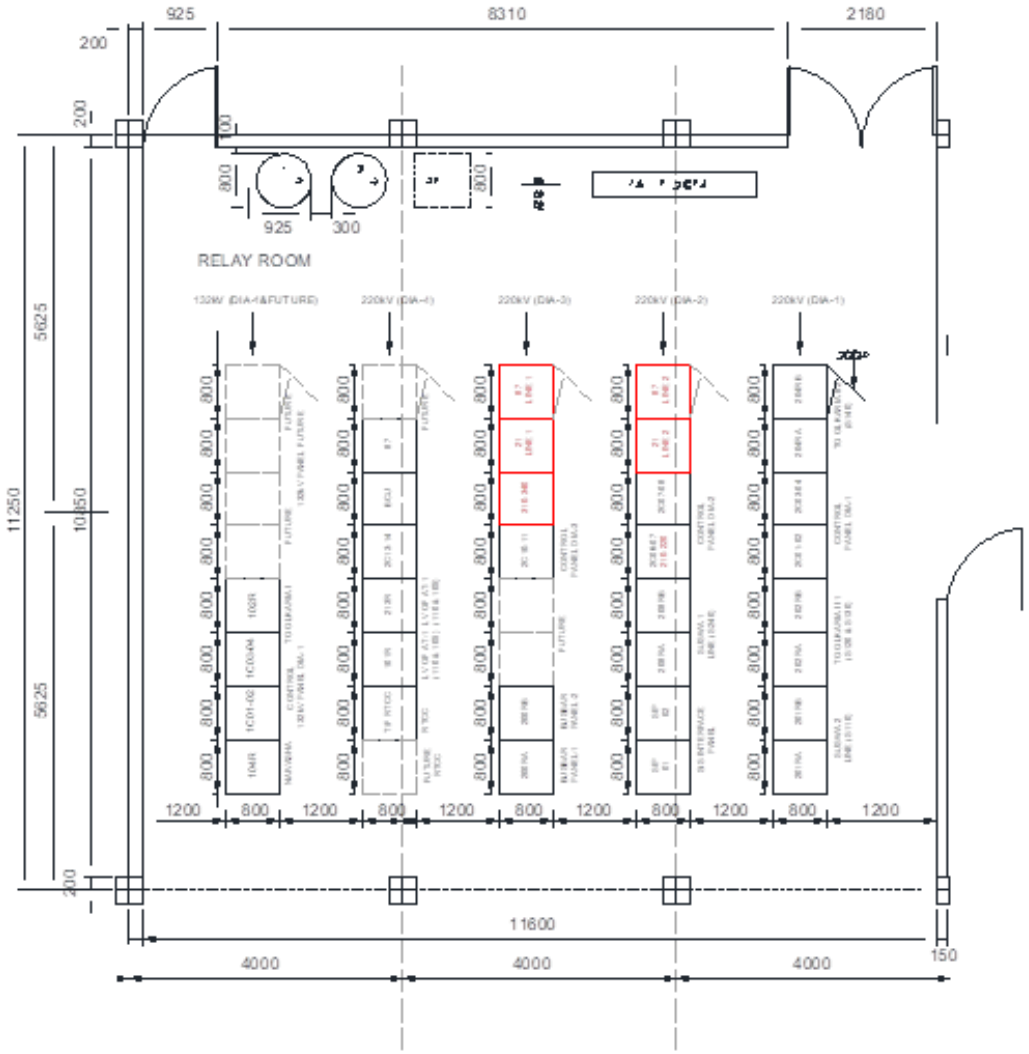
(Source: Olkaria VII F.S. Report)

Figure 3.3-23 Modification of the Olkaria-IAU Substation



(Source: Olkaria VII F.S. Report)

Figure 3.3-24 Single Line Diagram of the Modifications of the Olkaria-IAU substation



(Source: Olkaria VII F.S. Report)

Figure 3.3.25 Modification of the Olkaria-IAU Substation Control Room

3.3.5. Power system stability analysis

The results of the Power System Stability analysis are found attached as Annex-II of this Supplementary Study.

3.4. PROJECT IMPLEMENTATION PLAN

3.4.1. Outline (scope) of the Project

The Olkaria VAU implementation Project encompasses the following six (6) elements hereinafter briefly described:

- Owner's Engineer Services

The hiring of an Engineering Consulting Company with extensive experience in geothermal power plant construction which shall be entrusted the supply of technical services to Project Owner is a key in-advance activity. The said technical Services shall include the preparation of specifications of facilities, preparation of tender documents for EPC procurement of SAGS, power plant, and power evacuation system, and, among others, the review of the EPC Contractor detail design, supervision of quality control (including the evaluation of manufacturing process and attendance to factory tests) and, the supervision of construction works and power plant tests leading to its commissioning.

- Infrastructure revamping and/or construction

Encompasses the revamping of existing access roads leading to the projected well pads; construction of a water supply pipeline running from the water storage tanks accessed through Olkaria-II station to the planned Site of plant.

- Drilling of one reinjection well

During the implementation of the Olkaria-VII Feasibility Study it was noted that the cold reinjection capacity of the assigned reinjection well is not enough for the volume of condensate projected to be recovered from cooling tower blowdown and other sources. Therefore, drilling of at least one more reinjection well is necessary.

- SAGS construction

This scope includes the engineering, procurement and construction of three (3) separation stations, one venting station and approximately 22km of pipelines of different diameters comprising two-phase fluid conveying pipelines, steam pipelines, hot reinjection, cold condensate and steam traps pipelines. Pipelines supporting system and associated civil engineering works are included as well.

- Geothermal power plant construction

This scope includes the detail engineering, procurement and construction of a power generation plant of 80.3MW gross based on the single-flash technology with condensing steam turbine. Necessary mechanical, electrical, instrumentation and control, chemical, firefighting and other systems are envisioned to be engineered and installed as well.

- Power evacuation system and substation upgrade and construction

The power evacuation system includes a) construction of a step-up substation and switchyard at the Olkaria VAU plant. b) construction of a 220kV, double circuit and 2.7km long transmission line running from the new Olkaria VAU plant to the existing Olkaria IAU power plant substation. c) Enlargement of the Olkaria IAU substation through the addition of two bays and control room such that the power generated of the Olkaria VAU is injected into the Kenyan national grid.

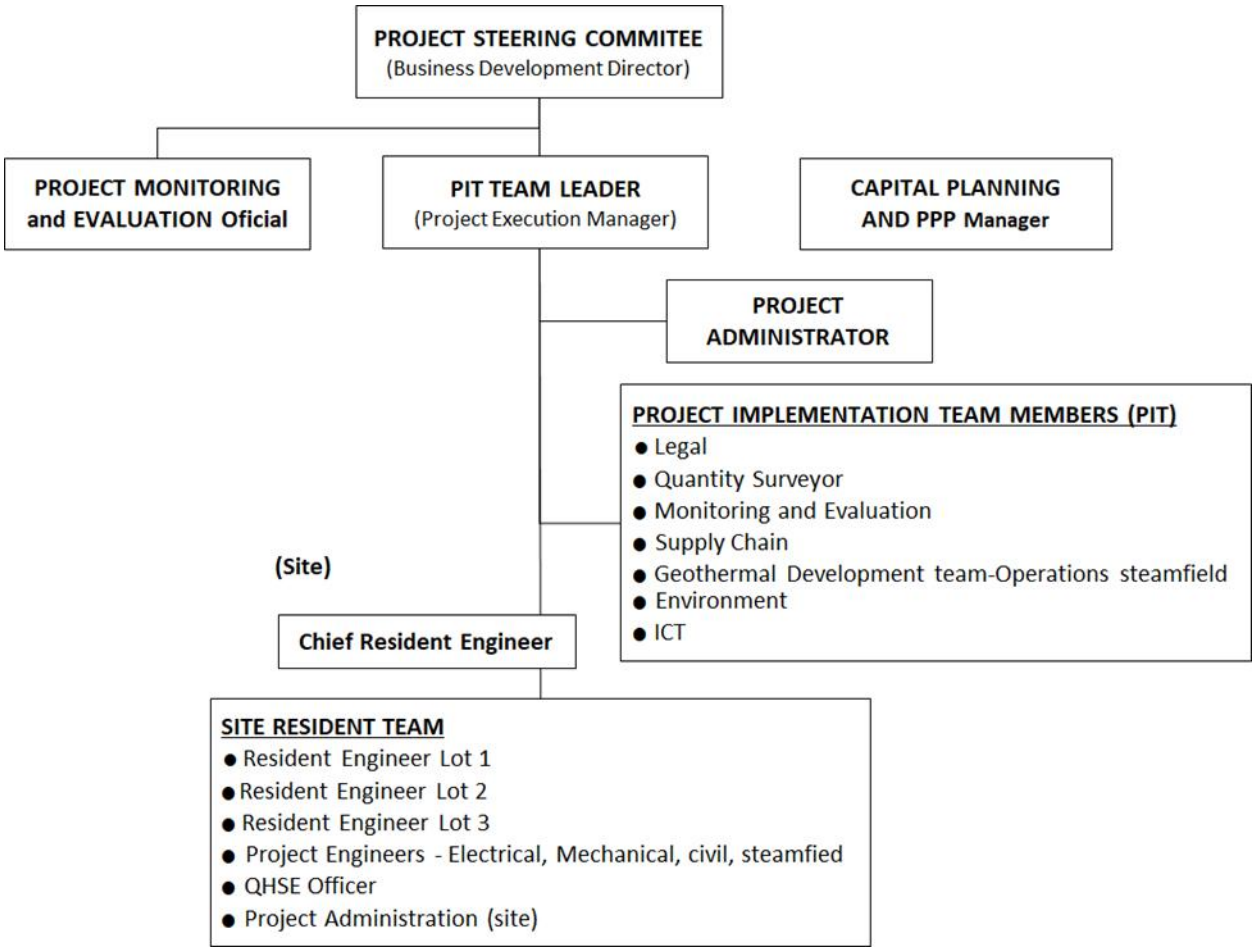
3.4.2. Organigram of KenGen for Project Implementation and Operation and Maintenance

(1) Organizational Structure for Project Implementation Team (PIT)

The execution of the Project will be under the responsibility of an appointed Project Execution Manager, or PIT leader, likely from the personnel of KenGen's Geothermal Development Division.

Figure 3.4-1 shows the proposed organization for the Olkaria-VAU Project implementation. The organization is based on the organigram implemented by KenGen at the time of construction of the Olkaria-IAU6 power plant.

Although personnel assigned to the PIT and/ or their functions will be different, KenGen is planning to put in practice the same or very similar structure for the implementation of the Olkaria VAU power plant. The KenGen's Site Resident Team would be added with one more Resident Engineer to take charge of the supervision of Lot 3, Substations and Transmission line contract (refer to sub-section 3.4.2.(2) below); as well, a Quality, Health, Safety and Environment officer (QHSE) is proposed herewith to be included within the Site resident Team.



(Source: adapted by Study Team)

Figure 3.4-1 Proposed organigram for the implementation of the Olkaria VAU Project

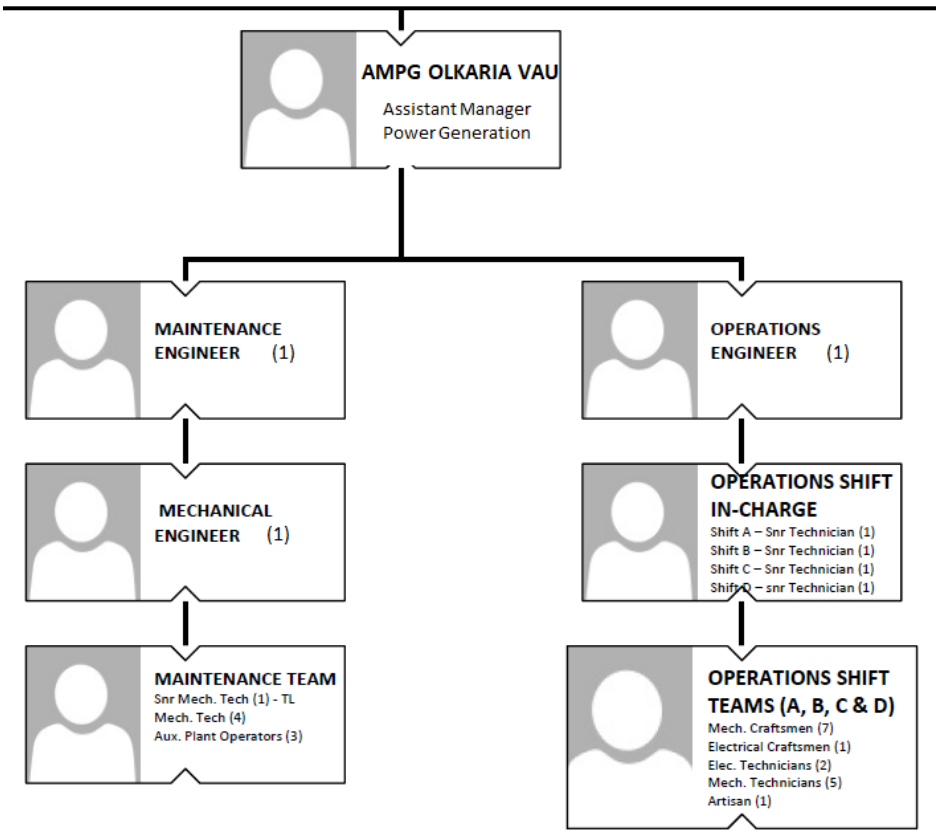
(2) Organisational Structure for Operation and Maintenance (O&M)

Figure 3.4-2 proposes an O&M organisation scheme for the new Olkaria V Additional Unit plant. It has been conceptualised based on the operation and maintenance organization of the Olkaria V and, in general, on the other KenGen geothermal plants operating in Olkaria.

The Operation Team of the Olkaria VAU would account on four (4) operation in-charge technicians divided into four shifts, supported by a group of sixteen technicians, craftsmen and artisan, which is also divided into four shifts. All the Operation Team will be working under an Operations Engineer.

Likewise, the plant Maintenance Team will be working under a Maintenance Engineer supervising the work of a Mechanical Engineer in-charge of a maintenance team of eight shifting technicians.

Other KenGen GPPs in Olkaria employs larger operation teams with up to eight (8) operation in-charge technicians and larger support groups with specialized functions. Therefore, the actual made up of the O&M team of the Olkaria VAU plant will be upon KenGen's criteria and actual needs.



(Source: KenGen; modified: Study Team)

Figure 3.4-2 Proposed O&M organogram for the new Olkaria VAU power plant

The operation and maintenance of the plant's steamfield will be under the responsibility of the much larger "Reservoir and Steamfield Unit", which works throughout the whole Great Olkaria field. A steamfield O&M group, a Reservoir group and, a Reservoir Chemistry group, comprises the Unit. The steamfield O&M group is made up of three (3) working teams, respectively each in charge of the Northeast sector, the Domes sector, and the East sector.

3.4.3. Undertakings to be implemented by KenGen

Infrastructure

1. The construction of the pipeline for tapping crude water from the water tanks located uphill the Olkaria –II geothermal power plant and conveying the liquid to the site of power plant construction.
2. Revamping and construction of roads leading to two-phase fluid production well pads, hot and cold reinjection well pads, as well to separation stations as necessary.

Geothermal development

3. Drilling of at least one cold condensate reinjection well before commissioning of the plant.
4. Implementation of production and reinjection testing on existing wells assigned to the Project where necessary.
5. Implementation of Reservoir Numerical Simulation, or its review should it be made by others.

3.4.4. Review of Construction Method

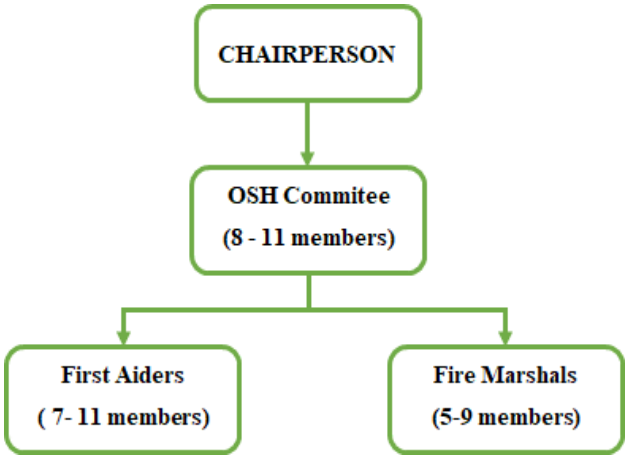
Items to be considered during Project implementation stage

- Access to site from Mombasa port to Nairobi available through the A-109 and A-104 National Roads, by-passing Nairobi and linking with the Moi-S Lake Road first and the Olkaria Route later to reach the plant Site all through bitumen grade roads.
- Above roads will allow easy transportation of heavy power generation equipment loads and, in case, oversized factory-crafted modular or pre-assembled sections besides the turbine-generator set components. For instance, although it took five days, back in 2021 the generator of the Olkaria-IAU6 totalizing 99 tonnes, was brought from port to Site without incident.
- Since heavy trucks are expected to have to access the Plant Site, the slope of the area comprising the Plant's gate and the adjacent roads intersection (refer to Figure 3.3-10) should be designed to be as gentle as possible.
- In order to ensure sufficient ground strength for structures on which heavy loads are installed, such the turbine-generator set, cooling tower, transformers and raw water tanks, careful consideration should be given to ground improvement and pile foundation design.
- The geotechnical survey implemented in the Feasibility Study reports the implementation of only three (3) borings holes to a deep of 20m each. Boring of more holes and excavated to enough depth such to reach bedrock is necessary.
- The civil engineering construction design shall consider the possibility of soil liquefaction and soil subsidence. All main structures must be designed as per Kenyan earthquake regulations.
- Proper wastewater treatment must be performed (i.e., turbid water should be separated into clear and murky water by installing a settling tank or tanks where from clear water is drained).
- EPC contractors shall duly educate locally hired workers in regard the duties to perform, safety measures and, recommend making use of close communication.
- Although the plant site area is big enough for the construction of a two-unit power plant, finding immediately close areas suitable for the essential in-advance delivery, lay-down and storage of goods and materials for at-site assembly, and, as well, for large-sized pre-assembled sections, may be challenging. Therefore, the EPC contractor must carefully plan the orderly inflow of materials to Site and, if emphasized, the delivery of pre-assembled sections.
- In general, the Olkaria area is not prone to severe weather conditions (heavy continuous rain, snow, high winds) which would make the overall construction schedule susceptible to delays, expose goods and materials to harsh weather conditions, and add concerns in regard work safety. However, equipment, materials and others stored outdoors shall be laid away from potential flooding. Safety countermeasures, such the monitoring of the prevailing weather and wind conditions at the time of works implementation and the operation of cranes, shall be duly adopted.
- To avoid delays and potential trouble with local residents, EPC contractors and KenGen may better deeply engage with the local communities (say, briefing sessions, tours, etc.) and always supply information timely and with transparency.

3.4.5. Review of Safety Measures during Construction

KenGen has supplied miscellaneous HSE framework records from the construction of Olkaria-IAU6 power plant and the Study Team has acknowledged KenGen's detailed management in regard Occupational Safety and Health -OSH-. Already back in 2018, KenGen achieved be awarded with the ISO 45001 HSE certification.

Similarly to the organization implemented at the time of the construction of the Olkaria IAU, Olkaria-IV and Olkaria-V power plants, a Project's Health, Safety and Environment system similar or equal to the shown below in Figure 3.4-3 shall be stablished.



(Reference source: KenGen; compiled: Study Team)

Figure 3.4-3 Typical HSE organization system for GPP construction in Olkaria

3.4.6. Packaging and Procurement Strategy

KenGen prefers to reduce the number of procurement Lots to a minimum number; this in contrast of dividing the procurement into smaller Lots, as it is proposed in the existing Feasibility Study.

While a bigger number of Lots could allow some flexibility in regard financial procurement, from the standpoint of Project Owner, smaller number of Lots is usually preferred for the sake of simplify Project's general management. On the other side, EPC contractors may also be more amenable of admitting cost reductions if Lots to bid for are larger.

The number of Lots KenGen intends to procure for the Olkaria VAU Project are the following:

- Lot 0 – Implementation Consultancy Contract,
- Lot 1 – Steamfield development (SAGS) Contract,
- Lot 2 – Power Plant construction Contract, and,
- Lot 3 – Substations and Transmission Line construction Contract.

Each of all above four Lots will be procured through International Competitive Bidding (ICB) conducted under the specific norms and guidelines of the entity financing each Lot, the regulations of the Executing Agency and the Laws of Kenya. PQ process for potential bidders will be implemented whenever required and regulated by the abovementioned guidelines, norms and regulations. All civil/infrastructure works within the scope of each Lot will be included in the Contract scope of the respective Lot.

The Project Owner's Engineer shall be involved with the preparation, implementation and evaluation of pre-qualification documents, bidding documents and the evaluation of tenders. Moreover, shall closely accompany contract negotiations, revise contracts and certify the compliance of contractors with those, among several other functions.

Similarly for Social-Environmental monitoring and implementation, KenGen foresees that each Contractor will be responsible for Implementation of the Environmental management plan within their respective Lot. The selected Owner's Engineer will monitor and ensure each Contractor is implementing and complying with the Environmental Management Plan.

3.4.7. KenGen's Risk Management

KenGen implements an Enterprise Risk Management (ERM) policy with the objective of managing business and operational risks in a structured and systematic manner. KenGen's ERM policy is designed to: (i) identify threats that affect the achievement of the Company's Vision, Mission and Values; (ii) take advantage of opportunities to create value for all stakeholders; and (iii) establish appropriate mitigation measures to counter the negative effects of the risks [4].

The Board of Directors, Figure 3.4-4, through its Audit, Risk & Compliance Committee, exercises the oversighting role in the ERM processes implemented by the Management. KenGen has adopted a Risk Management Framework based on the ISO-31000 International Risk Management Standard, including control activities of the Committee of Sponsoring Organizations [5]. KenGen has also adopted the "Three Lines Model" to continue supporting the effective implementation of the ERM framework. The Three Lines Model helps KenGen to identify structures, processes, roles, and responsibilities that best assist the achievement of objectives and facilitate strong governance and risk management. [5].

KenGen's Management, Executive Committee, Board, and Audit & Risk Committee provide oversight on the management of principal risks and internal control systems to ensure effective risk governance by implementing relevant policies for risk management. This oversight involves examining internal audit reports and reviewing outcomes of business processes, including strategy, planning, and resource and capital allocation. KenGen's risk management team evaluates the Company's risk profile and maintains the risk management system. The internal audit team provides independent assurance to the MD & CEO and the board, confirming that the internal control system is well designed and functioning effectively to address significant risks faced by KenGen [6].

The summary of perceived key risks and adopted mitigation strategies [6] is detailed in Appendix I-5.



Figure 3.4-4 KenGen's Risk Governance Framework [6]

3.4.8. Project Implementation Schedule

The Study Team has updated the Project implementation schedule as it is shown in Figure 3.4-5 following this sub-section. The update reflects the implementation schedule discussed with KenGen at the time of the Olkaria-VII Feasibility Study; in addition, it considers relevant communications with KenGen.

[4] KenGen, Integrated Annual Report & Financial Statements for the Year ended 30 June 2017. Page 130

[5] KenGen, Communication on Progress Report 2021. Page 23

[6] KenGen, Integrated Annual Report & Financial Statements for the Year ended 30 June 2024. Page 116-120

	ACTIVITY	Financing	year / Month	2025 (6 7 8 9 10 11 12)	2026 (1 2 3 4 5 6 7 8 9 10 11 12)	2027 (1 2 3 4 5 6 7 8 9 10 11 12)	2028 (1 2 3 4 5 6 7 8 9 10 11 12)	2029 (1 2 3 4 5 6 7 8 9 10 11 12)	2030 (1 2 3 4 5 6 7 8 9 10 11 12)	2031 (1 2 3 4 5 6 7 8 9 10)
	LOAN AGREEMENT (L/A)				Appraisal Mission; Project L/A					
ENVIRON	ENVIRONMENTAL & SOCIAL IMPACT: MONITORING and ASSESSMENT									
	(1) Monitoring of Environmental Impact and Mitigation		57.0							
	(2) Monitoring of Social Impact and Mitigation		57.0							
ENGINEERING SERVICES	PROCUREMENT of ENGINEERING CONSULTANT for KENGEN	Financer Finance	8.0							
	(1) Preparation of Prequalification documents and TOR. Letter of Invitation and post		2.0							
	(3) Tender preparation by Bidders		2.0							
	(4) Prequalification	by	0.5							
	(4) Evaluation of Technical Proposals.	KenGen	1.5							
	(5) Evaluation of Financial Proposals		0.5							
	(6) Contract Negotiation,		0.5							
	(7) KenGen internal Approval and Signing		1.0							
	Engineering Consulting Services for KenGen		57.0							
SAGS PROCUREMENT AND CONSTRUCTION	STEAMFIELD ABOVE GROUND SYSTEM	Financer / Finance								
	Procurement of SAGS Contractor		15.0							
	(1) Review of previous studies		0.5							
	(2) Design and Engineering -Preparation of Project Design Report -		2.0							
	(3) Preparation of Pre-qualification Documents		1.0							
	(4) Concurrence with P/Q Documents by Financer		0.5							
	(5) P/Q Announcement and P/Q Application submission by Prospective Bidders		1.5							
	(6) Evaluation of P/Q Application		1.0							
	(7) Concurrence of Financer with P/Q Application Report		0.5							
	(8) Preparation of Tender Documents and KenGen approval		2.0							
	(9) Concurrence of Financer with Tender Documents		0.5							
	(10) Tender Period		2.0							
	(11) Evaluation of Tender (Technical) and KenGen Approval		1.5							
	(12) Concurrence with Technical Evaluation Results by Financer		0.5							
	(13) Evaluation of Tender (Price) and KenGen Approval		1.0							
	(14) Concurrence of Financer with Price Evaluation results		0.5							
	(15) Contact Negotiation, KenGen approval and Signing		1.0							
	(16) Concurrence of Financer with Contract		0.5							
	(17) Letter of Credit opening	by	1.0							
	Construction of the Steam Field Ground System SAGS (by SAGS EPC Contractor)	KenGen	25							
	(1) Design, Fabrication, shop Inspection, delivery of Equipments and Materials		20							
	(2) Civil Works		18							
	(3) Erection and instalallation of pipelines and Equipment		14							
	(4) Pre- Commissioning and Commissioning		3							
PLANT EPC PROCUREMENT	PROCUREMENT OF EPC CONTRACTOR FOR PLANT CONSTRUCTION		14.0							
	(1) Review of previous studies		0.5							
	(2) Design and Engineering - Preparation of Project Design Report		4.0							
	(3) Preparation of Pre-qualification Documents		1.0							
	(4) Concurrence of Financer with P/Q Documents		0.5							
	(5) P/Q Announcement and P/Q Application submission by prospective Bidders		1.5							
	(6) Evaluation of P/Q Application		0.5							
	(7) Concurrence of Finanacer with P/Q Application Report		0.5							
	(8) Preparation of Tender Documents and KenGen approval		2.0							
	(9) Concurrence of Financer with Tender Documents		0.5							
	(10) Tender Period		3.0							
	(11) Evaluation of Tenders (Technical) and KenGen approval		1.5							
	(12) Concurrence of Financer with Technical Evaluation Results		0.5							
	(13) Evaluation of Tender Price and KenGen approval		1.0							
	(14) Concurrence of Financer with Price Evaluation Results		0.5							
	(15) Contact Negotiation, KenGen approval and Signing		1.5							
	(16) Concurrence of Financer with Contract		0.5							
	(17) Letter of Credit opening	KenGen	1.0							
PLANT CONSTRUCTION	GEOTHERMAL POWER PLANT CONSTRUCTION (by PLANT EPC CONTRACTOR)		30.0							
	(1) Mobilization		1.0							
	(2) Site Preparation (Topographical Survey, Soil Investigation, Slope protection, etc.)		10.0							
	(3) Detail design, Manufacturing, Shop Inspection, and Delivery of Equipment and Materials		20.0							
	(4) Foundations, Concrete Structures, Buildings and Roads		14.0							
	(5) Erection, Installation of Equipments and Materials (Unit 1)		12.0							
	(5) Commissioning of Unit 1		3.0							
WARRANTY	POST CONSTRUCTION STAGE									
	Warranty Period		18.0							
	(1) Steam Above Ground System SAGS		12.0							
	(2) Power Plant Unit 1									
POWER EVACUATION	TRANSMISSION LINE for POWER EVACUATION									
	Survey and basic design		7.0							
	Pre-Construction (Procurement Process)		10.0							
	Construction Stage		8.0							
	(1) 220kV Transmission Line (Olkaria-VII to Olkaria-IAU sub-station)		6.0							
	(2) Construction Olkaria-VII Substation		13.0							
	(2) expansion and upgrading of the Olakarua-IAU GPP expansion		6.0							
	(3) Commissioning of the transmission Line and Substation expansion		2.0							
			Month / year	6 7 8 9 10 11 12 / 2025	1 2 3 4 5 6 7 8 9 10 11 12 / 2026	1 2 3 4 5 6 7 8 9 10 11 12 / 2027	1 2 3 4 5 6 7 8 9 10 11 12 / 2028	1 2 3 4 5 6 7 8 9 10 11 12 / 2029	1 2 3 4 5 6 7 8 9 10 11 12 / 2030	1 2 3 4 5 6 7 8 9 10 / 2031

Steam supply for Pre-commissioning; COD Unit-1 80MW; end waranty period Unit-1 80W; Power availability for construction; Power availability for erection, installation and pre-commissioning activities; end waranty period SAGS

Figure 3.4-5 Construction Project implementation Schedule

3.5. PROJECT PERFORMANCE INDICATORS

3.5.1. Plant Availability and Capacity factor

To address plant performance indicators, the averaged results of operation records regarding plant availability and plant capacity factor corresponding to KenGen's newest Olkaria geothermal power plants and collected through six years fiscal years, FY2018 to FY2023, were utilised. However, since there were several restrictions during the years affected by the COVID -19 pandemic (broadly, FY 2020-2021 and FY 2021-2022) those two Fiscal Years were dropped from the evaluation.

Therefore, considering the years of "normal operation" only, the average plant capacity factor reached 84.7% at 94.5 of plant availability. These two figures for plant availability and plant capacity factor are similar to the 95% and 85% performance indicators commonly utilized in the geothermal generation industry for single flash plants, therefore, were adopted within this Supplementary Study.

3.5.2. Project Targeted Outcomes

The performance of technical indicators targeted to be attained through the years of the Olkaria VAU Project operation is proposed in Table 3.5-1 below. The first evaluation shall be carried out two years after Project commissioning.

Table 3.5-1 Operational Targets

Indicator	Target value after two years from COD	
Maximum Gross output	80.3 MW	
Net Output	76.14 MW	
Capacity Factor	85%	
Availability Factor	95%	
Outage hours by cause	Scheduled shutdown:	312 hrs/ year
	Forced outage (plant failure):	126 hrs/ year
	Forced outage (human error):	0 hrs/ year
Number of outages for every cause	Maintenance stop:	1 time/year

(Source: Study Team)

3.5.3. Reduction of the emission of greenhouse gases

(1) Calculation method

The implementation of this project is expected to reduce fossil fuels use and contribute to mitigating climate change through curbing GHG (greenhouse gas) emissions, The reduction effect in greenhouse gas emission was estimated using the JICA Climate Finance Impact Tool Version 5.0, March 2024.

The reduction of GHG emissions (ER) through the life span of the project were calculated as the difference between the GHG emissions equivalent to the amount of conventional energy replaced by the renewable energy power generation facility (BE: emissions under the baseline scenario) and the GHG emissions after the renewable energy power generation facility is operational (PE: project emissions). The supply form of generated electricity was assumed to be grid connection. The calculation formula is as follows (for details, refer to "JICA Climate Finance Impact Tool Version 5.0, March 2024").

$$ER_y = BE_y - PE_y$$

ERy: GHG emission reduction through the project in year y (t-CO2e/y)

BEy: GHG emission from the baseline scenario in year y (t-CO2e/y)

PEy: GHG emission from the project scenario in year y (t-CO2e/y)

$BE_y = EG_y \times EF_{elec}$

EGy: Power generation by the renewable energy system in year (MWh/y)

EFelec: CO2 emission factor of the electricity (t-CO2/MWh)

$PE_y = PES_y + PEEF_y$

PESy: CO2 and CH4 emissions associated with steam production (t-CO2/y)

PEFFy: CO2 emission associated with fuel consumption at the power plant (t-CO2/y)

$PES_y = \left(W_{Main,CO2} + W_{Main,CH4} \times GWP_{CH4}\right) \times M_{S,y}$

wMain,CO2：Average mass fraction of carbon dioxide in the produced steam (t-CO2/t)

wMain,CH4：Average mass fraction of methane in the produced steam (t-CH4/t)

GWPCH4：Global warming potential of methane

MS,y：Quantity of steam produced in year "*y*" (t)

$PEFF_y = \sum_i \left(FC_{i,y} \times NCV_i \times EF_{fuel,i} \div 10^6\right)$ [1]

FCi,y：Consumption of fossil fuel "*i*" at the power plant in year "*y*" (t/y)

NCVi：Net calorific value of the fossil fuel "*i*" (TJ/Gg = TJ/kt)

EFfuel,i：CO2 emission factor of the fossil fuel "*i*" (kg-CO2/TJ)

(2) CO_2 emission factor of the grid electricity

The CO2 emission factor of the grid electricity used was 0.274 (t-CO2 / MWh) for the electricity grid in Kenya in "JICA Climate Finance Impact Tool Version 5.0, March 2024, Appendix 3: Electricity Grid." The global warming potential of methane was set at 25.

(3) Input Conditions

The planned output capacity, annual utilization rate, and power generation capacity of the power generation facilities subject of this Study are shown in Table 3.5-2.

(4) Calculation result of GHG emission reduction through the project

The GHG emission reduction through the geothermal power generation plan with a net output of 76 MW is 133,471 (t-CO2e/y).

[1] Since no fossil fuels are used, the values of FCi, y, NCVi, EFfuel, i are all set to 0.

Table 3.5-2 Calculation conditions for GHG emission reductions

Calculation Conditions	
1.Geothermal Power	
Planned sending-end output of power generation facility (refer to 3.3-3)	76.14MW
Capacity factor of the power plant (refer to 3.6.xx)	85%
Total electricity produced by the project activity (EGy = 76.1MW x 8,760h/year x 85.0%)	569,938MWh/ year
2. Quantity of steam, etc.	
Steam consumption at the geothermal power plant of this project (refer to 3.3.1(1))	482.5 t/h
Quantity of steam produced in year (MS, y = 482.5t/h x 8,760h/year)	4,226,700 (t/year)
Quantity of non-condensable gas in steam (refer to 3.2.1)	0.5% in weight
Amount of CO2 in non-condensable gases in steam (refer to 3.2.1)	86% in weight
Amount of methane in non-condensable gases in steam (refer to 3.2.1)	0.3% in weight
Average mass fraction of carbon dioxide in the produced steam (wMain,CO2 = 0.5% x 86%)	0.0043(tCO2/t)
Average mass fraction of methane in the produced steam (wMain,CH4 = 0.5% x 0.3%)	0.000015(tCH4/t)
3. CO2 emission factor of the grid electricity	
CO2 emission factor of the grid electricity (EFelec) (JICA Climate Finance Impact Tool Version 5.0, March 2024. Appendix 3)	0.274 (t-CO2/MWh)
Global warming potential of methane (GWPCH4) (JICA Climate Finance Impact Tool Version 5.0, March 2024. 15. Renewable Energy / Solar, Wind and Others)	25

(Source: Study Team)

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. CONCLUSIONS

The objective of the Supplementary Study is to evaluate the appropriateness of the geothermal development plan for Olkaria V Additional Unit as a project financed by an ODA Yen loan by examining the existing Feasibility Study Report and other relevant materials.

The review of the existing Olkaria-VII Feasibility Study Report revealed that it is specifically intended for the development of Olkaria V Additional Unit in both its upstream (geothermal resource) and downstream (surface facilities) implementation stages. In addition to the existing documents, materials and data that could be used to evaluate the development plan for the Olkaria V Additional Unit were collected from KenGen, KPLC and KETRACO. Interviews with relevant stakeholders, on-site investigations and supplementary data analysis were also conducted. The appropriateness of the Olkaria V Additional Unit development plan was examined by integrating all the information collected together with the existing feasibility study report.

As result, it was determined that, from the perspective of geothermal resources, it is possible to develop a gross output equivalent of 80.3MW (net output of 76.14MW). This conclusion is based on the following facts: a) production tests of the existing wells assigned to the Olkaria VAU Project have confirmed availability of more than 100% of the required steam; b) it is expected that the reinjection capacity can be secured, and, c) 80.3MW output can be maintained for the next 25 years through the implementation of make-up wells drilling..

In addition, the well drilling plan described in the existing Feasibility Study Report was reviewed with based on the confirmation of the Steamfield Above Ground System (SAGS) plan and the power plant construction plan.

Project implementation costs were revised in consideration of recent global plant cost fluctuations. Similarly, cost of the power evacuation system for connecting the Olkaria V Additional Unit to the existing substation of the Olkaria IAU plant was revised along all Project. In addition, The Study Team evaluated and updated the project implementation schedule to the current circumstances. Subsequently, revision of the economic and financial analysis was performed.

Regarding the power plant, the site recommended for the Olkaria V Additional Unit is a gently sloping area measuring approximately 380m x 200m between well pads OW-03 and OW-36. This location has the advantage of being outside the National Park, far from the communities, easily accessible and without interference with existing facilities. The installed capacity and steam requirement of the power plant are estimated as follows:

Power generation system:	Single-flash cycle with condensing steam turbine
Number of units:	1 unit
Steam consumption:	482.5 t/h
Gross output:	80.3 MW
Parasitic load:	4.2 MW
Net output:	76.14 MW

Regarding fluid transportation, the mixture of steam and brine produced from the production wells will be conveyed to three Separator Stations through two-phase fluid pipes; the separated steam will be sent to the power plant, and the hot brine and condensate will be returned to the underground via reinjection wells.

The 220 kV double circuit transmission line will connect the Olkaria V Additional Unit substation to the Olkaria I Units 4-6 substation over approximately 2.7km.

The proposed project implementation schedule tentatively assumes all relevant loan agreements (L/A) should had been concluded by the end of March 2026 and foresees that the Olkaria V Additional Unit will begin commercial operation by the end of 2029.

This Study assumed that funding would be obtained from the EIB and from the not executed portion of the ODA loan granted at the time of construction of the Olkaria V geothermal power plant, currently owned and operated by KenGen.

Financial Evaluation

As result of the financial analysis, the electricity tariff for achieving FIRR (Financial Internal Rate of Return) equal to the WACC (Weighted Average Cost of capital) of the Project (3.54%) was calculated to be USD ₵7.49per kWh.

In other words, the LCoE (levelized cost of electricity) of the Project is USD₵ 7.49 per kWh. Taking into consideration that the LCoE from geothermal power projects in Kenya range between USD 4₵ and USD₵14 per kWh, the LCoE of the Olkaria V additional unit (USD₵ 7.49 per kWh) could be regarded as reasonable.

Results of sensitivity analysis revealed that the changes in O&M costs and interest rate have relatively smaller impact on LCoE, while changes in capital costs and capacity factor have larger impact on LCoE. The LCoE of the Project will be exceeding USD₵ 8.0 per kWh, when the capacity factor is lower than 78% or the capital cost overrun higher than 15%.

On the other hand, DSCRs (debt-service coverage ratio) are always well above the sufficient level of 1.2 under the various adverse scenarios simulated, thereby it is judged that KenGen will have sufficient cash from the Project to repay loan.

Economic Analysis

The economic benefits of the Project consist of i) the avoided costs of an alternative power plant and ii) CO_2 reduction effects. Among the three candidate generation technologies suitable for based-load, LNG-based Combined Cycle Gas-turbine was selected as the alternative power plant.

The economic internal rate of return (EIRR) of the Project was calculated to be 14.28%, which is higher than the Economic Opportunity Cost of Capital in the country (11.50%).

Also, the Economic Net Present Value (ENPV) and Cost Benefit Ratio (B/C) were calculated to be USD 66.2million and 1.18, respectively. Both the ENPV and B/C are above the thresholds (ENPV>0. B/C>1.0). Thereby the Project is judged to be economically feasible from point of view of the national economy.

Result of sensitivity analysis clarified that the economic feasibility of the Project will not be lost even when either the capital costs or the O&M costs increase by 30% each. The EIRR is relatively sensitive to changes in capacity factor; however, the economic feasibility will not be lost even when the capacity factor becomes 70%, that is, 15% lower than the original assumption of 85%.

4.2. RECOMMENDATIONS

4.2.1. Geothermal Resource

- In order to maintain stable power plant output in the future, it is advisable to conduct reservoir numerical simulations based on the projected installed capacity, the required steam amount and, the planning for well operation of the power plant to be constructed as Olkaria V Additional Unit and to formulate an optimal well operation plan.
- For hot brine reinjection wells, it is recommended to carry out injection tests of OW-805D, OW-3, and OW-11 to confirm the injection capacity. After confirming the total injection capacity of the reinjection wells, the optimal redundancy should be reconsidered while comparing it with the total brine volume.
- Regarding condensate reinjection wells, it is recommended that injection tests be conducted on newly drilled condensate reinjection wells to confirm their injection capacity.
- It is desirable to analyse data relating to scaling (type of scale, location, rate of scale formation etc.) from wells allocated to Olkaria V Addition Unit or adjacent wells in order to verify the conclusions of the existing Olkaria-VII Feasibility Study report regarding scale.
- It is also advisable to carry out detailed investigations of all the production wells assigned to the Olkaria V Additional Unit Project (TFT tests at various wellhead pressures, mass flow and enthalpy measurements, chemical analysis of brine and non-condensable gases) to enable equipment design that takes into account not only scaling countermeasures but also possible long-term changes in reservoir properties.
- It is recommended that the “control points” established in the field at the time of topographical survey implementation within the target area to be maintained for its use in the next phase of the Project.

4.2.2. Financial- Economic evaluation

The Financial analysis indicated that the Project could generate electricity at relatively reasonable price (LCoE = USD¢ 7.49 per kWh) and could generate sufficient revenue to repay the loans. Likewise, results, of the economic analyses indicated that the Project is economically feasible from the standpoint of the national economy.

However, since the results of sensitivity analysis revealed that capital costs overrun and reduction in the capacity factor have relatively large impact on the Financial and Economic feasibility, it is recommended that KenGen to especially place higher importance on: i) strict cost management during construction to avoid cost overruns; and, ii) to implement proper routine and periodic maintenance activities to keep the capacity factor at the target level (85.0%).

END of the

SUPPLEMENTARY STUDY FINAL REPORT

Supplementary Feasibility Study for Olkaria V Geothermal Power Plant Additional Unit Project

ANNEXED DOCUMENTS

February 2026

West Japan Engineering Consultants, Inc.

ANNEX-I

FINANCIAL AND ECONOMIC CONSIDERATIONS & OTHERS

ANNEX-I

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APPENDIX I-1

Evaluation of the CAPEX determination process

1. EVALUATION OF CAPEX DETERMINATION PROCESS

This Appendix develops considerations relevant with the appropriateness of the proposed budget within the Olkaria-VII Feasibility Study and explores the possibility of cost reduction.

In general, the Study Team determined that the estimated Project CAPEX for the Project adequately reflects averaged costs found in the geothermal power generation industry. Neediness to remark that the word "averaged" implies that, should the Project implementation be tendered, the actual cost proposed by any bidder may be either lower or higher than the cost budgeted in sub-section 13.2, Chapter 13 of the Supplementary Study.

In regard the possibility of cost reduction, each of the procurement Lots has been re-evaluated and, where possible, some optimization was made. Nevertheless, the possibility of significant Project cost reduction was not found.

1.1. LOT 0: ENGINEERING SERVICES

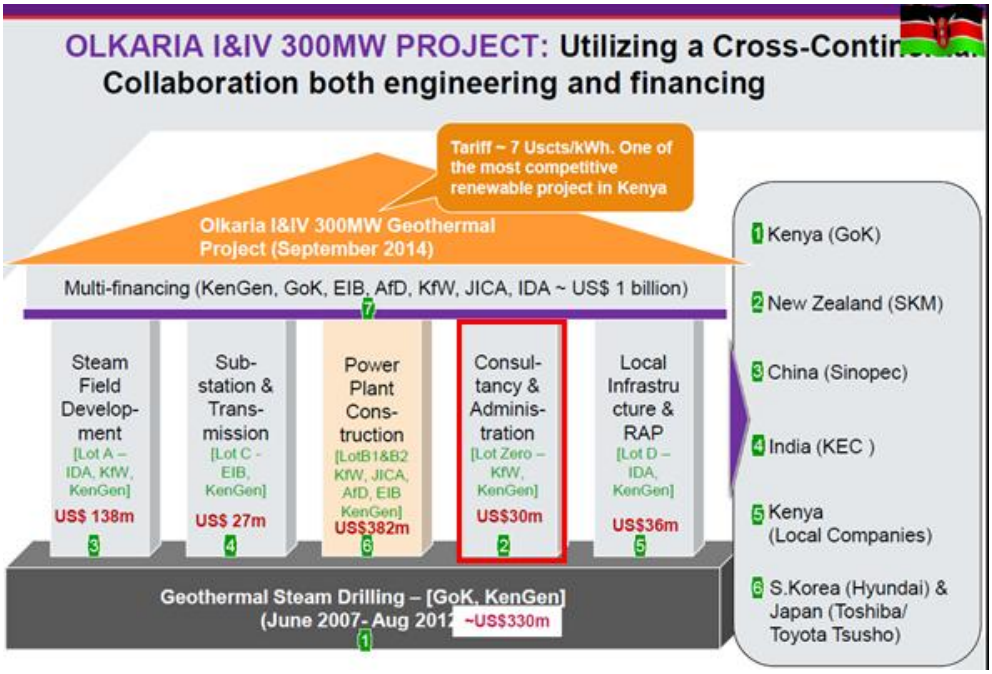
Cost of Engineering Services shown in the Olkaria-VII F.S. were estimated from the Consultant's data and adjusted to the dollar purchasing value. The Consultant built the said database through several years by registering the amounts of winning bids of several International Competitive Biddings of geothermal power plant construction on which the Consultant participated and, as well, by registering data from other sources.

For the Olkaria-VII Feasibility Study, the estimation was made from two sources within the said data base:

a) The averaged result of winning Bids of Indonesian GPPs construction projects, whether awarded or no to the abovementioned Consultant, and to which escalation was applied. Facts such whether the SAGS was included or not, and, whether drilling supervision was included or not in the scoped Services were considered.

b) KenGen's budget relevant to Engineering Consulting Services for the Olkaria I&IV 300MW project, two 2x75MW each power plants. The cost estimated was 30million, (cost estimation presented on 2014, refer to Figure 1-1).

The average of above a) and b) turned into a rounded estimation for Engineering Services fee that the Study Team regards as reasonable.



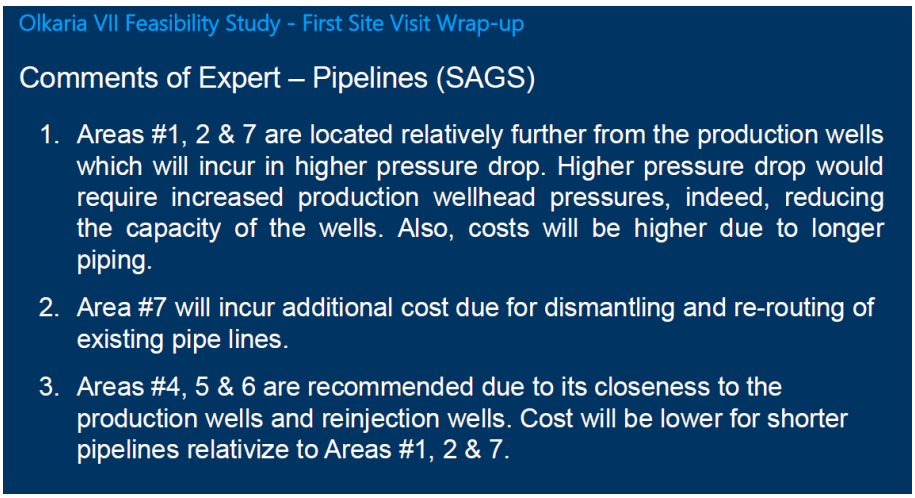
Source: Geothermal Exploration and Development in Kenya, C. Karingithi presentation, Naivasha.

Figure 1-1 Olkaria I&IV 300MW Project Financing, 2014

1.2. LOT 1: SAGS

As mentioned in 1.3.1 of this Annex, although the length of pipelines required to reach Site 1 from the Separation Stations was determined to be longer than to other potential plant site locations, the Consultant and KenGen also determined the existence of fewer impact environmental constrictions, which weighted more in the overall evaluation.

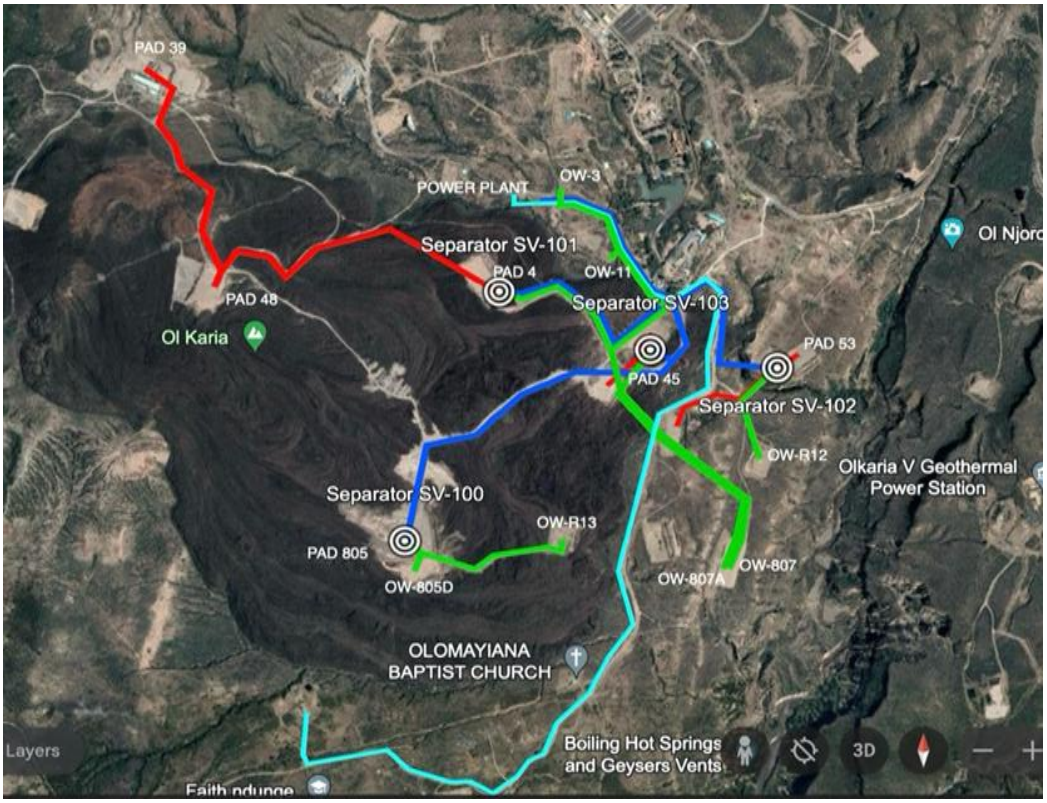
Preliminary evaluation is shown in Figure 1-2, excerpts of the discussion between the Consultant and KenGen personnel at the Olkaria-VII F.S. Project commencement meeting held on April 2023.



(Source: Study Team)

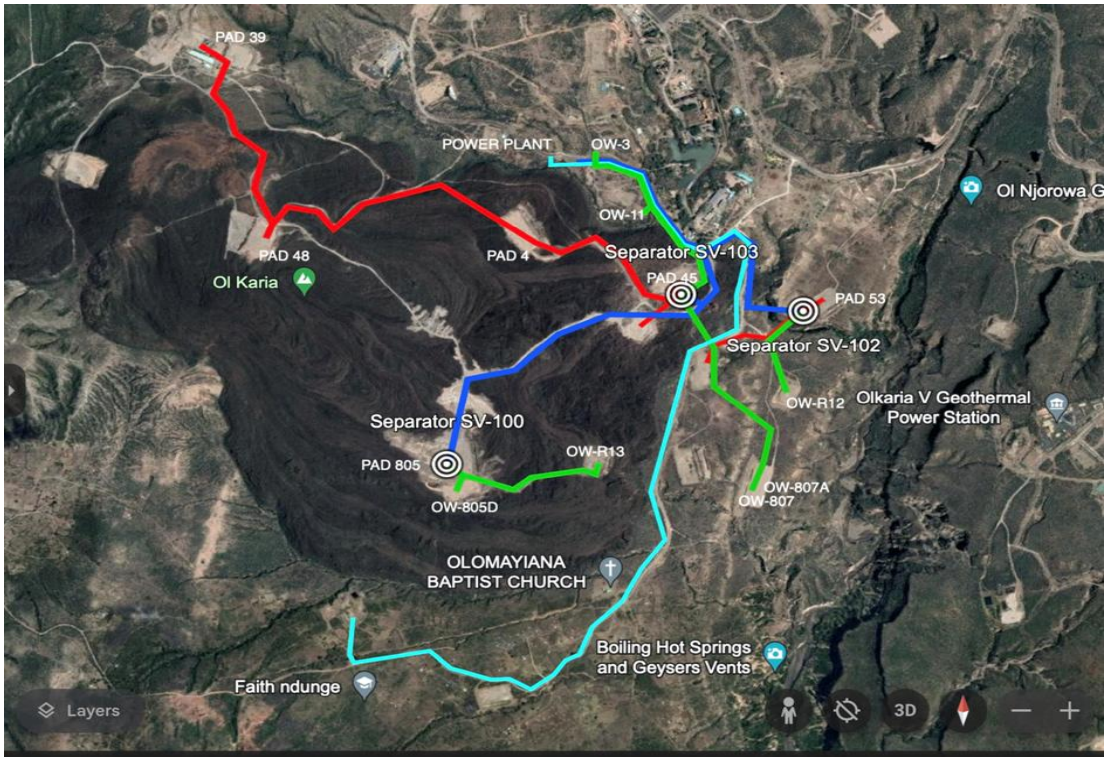
Figure 1-2 Excerpts on SAGS, wrap-up meeting of April 2023

In addition, during Olkaria VII F.S, KenGen proposed two SAGS alternative layouts (Figure 1-3 and Figure 1-4); however, none of them satisfied ideal technical conditions, nor their cost was lower.



(Source: Olkaria-VII F.S. Report)

Figure 1-3 SAGS Lay-Out (Alternative 1)



(Source: Olkaria-VII F.S. Report)

Figure 1-4: SAGS Lay-Out (Alternative 2)

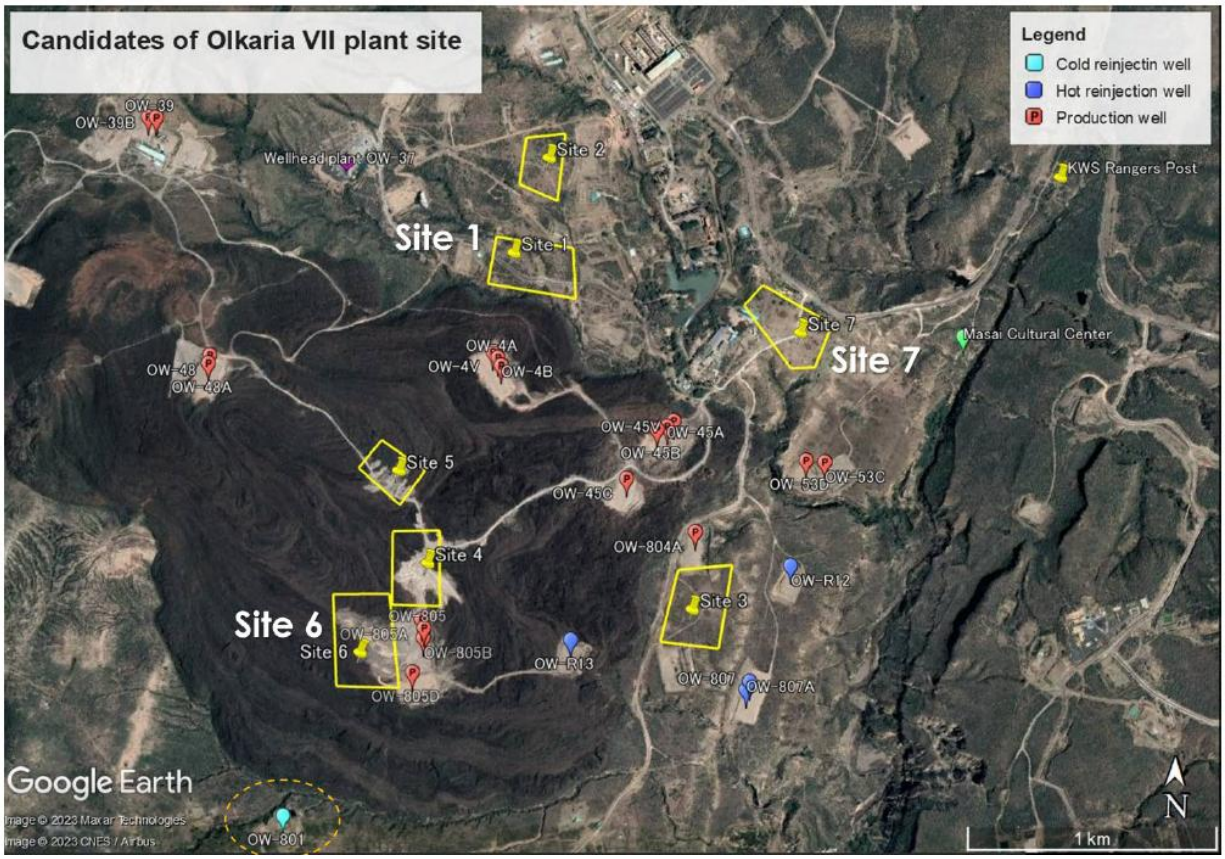
1.3. LOT 2: POWER PLANT

1.3.1. Power Plant Site selection

The site selected for the Olkaria-VAU plant construction was selected among seven available alternatives or candidate sites (Figure 1-5).

After preliminary considerations accrued at the time of wrapping-up the commencement meeting held in Olkaria on April 2023 (Table 1-1), based on technical-economic analysis, including the preliminary evaluation of the magnitude of necessary civil works to implement and social-environmental considerations (Table 1-2), three (3) sites were picked out as they were considered to be the most suitable for hosting a power plant.

In addition of the technical analysis and cost comparison among the above-mentioned three sites (Table 1-3), environmental considerations were also weighted at the time of selecting Site 1 as the most appropriate location for Plant Site.



(Source: Olkaria-VII F.S. Report)

Figure 1-5 Preliminary locations for power plant site

Table 1-1 Preliminary considerations for the selection of Plant Site (April 2023)

Olkaria VII Feasibility Study - First Site Visit Wrap-up

Comments of Expert – Civil Engineering

	Site 1	Site 2	Site 3	Site 4
Availability of flat space	3 – Slight sloping terrain	2 – Quite a sloping terrain	4 – A flat terrain	0 – Quarry area with very rugged terrain
Space for future expansion	2 – limited by nearby well pads	2 – limited by existing power lines & pipelines	4 – Area has room for expansion	0 – Quarry with a nearby deep hole
Drainage - Catchment Area	2 – Has large catchment area from nearby hills	3 – Has sizeable catchment area from nearby hills	1 – Has a very large catchment area since at very low elevation	0 – Being a quarry, drainage works would be a challenge
Access - through Murram or Tarmac Road	4 – Next to Tarmac Road	4 – Next to Tarmac Road	3 – Along usable Murram road	3 – Along usable Murram road
Soil stability (erosion, land slide)	3 – Only slightly slopy and storm drains will sort out erosion.	3 – Only slightly slopy and storm drains will sort out erosion.	4 – at a wide flat area and storm drains will sort out erosion	2 – expansion of area may extend to nearby pit that may not be stable
Cost for civil works – Earthworks, Retaining wall, Storm drains	3 – Earthworks mainly drainage works and some levelling works	3 – Earthworks mainly drainage works and some levelling works	3 – Earthworks mainly drainage works	1 – Extensive earthworks to level up the area and fill up deep pit for extended area

	Site 5	Site 6	Site 7
Availability of flat space	2 – Quite a rugged terrain	1 – sloping and rugged terrain	4 – A flat terrain
Space for future expansion	1 – Area may not fit 2 plants without extensive civil works	4 – Area has room for expansion	1 – Area may not fit 3 plants due to nearby deep gulleys
Drainage - Catchment Area	2 – Has large catchment area from nearby hills	4 – very small catchment area with areas around sloping away	3 – Has sizeable catchment area from nearby hills
Access - through Murram or Tarmac Road	3 – Along usable murram road	2 – A little off the usable murram road	4 – Next to Tarmac Road
Soil stability (erosion, land slide)	1 – will have steep slope on one end that may not be stable	3 – area sloppy but formation on rocky material thus stable	4 – at a wide flat area and storm drains will sort out erosion
Cost for civil works – Earthworks, Retaining wall, Storm drains	1 – Major earthworks for leveling & retaining walls for extended area	2 – Extensive earthworks to level up the area	3 – Earthworks mainly drainage works

(Source: Olkaria-VII F.S. Team)

Table 1-2 Environmental constrictions considered for selection of Plant Site

Comments of Environmental Expert	
Area 1:	The area is located in close proximity to the Hell's Gate National Park.
Area 2:	The area is located within the Hell's Gate National Park, hence, may experience difficulties in getting license from NEMA. In addition, the international funding community might find it difficult cooperating a Project inside a protected area
Area 3:	Close proximity to Ole Maiyan-kubwa village. It is likely that selection of this site will attract a Remediation Action Plan (RAP).
Area 4:	Although it is not obvious, this area is also close proximity to Ole Maiyan kubwa (1.5 km approx.)
Area 5:	The area is adjacent to the Ol Butot lava flow area (a rugged lava flow formation)
Area 6:	Unique habitat to the Dik-Dik small antelope; further disturbance of the Ol Butot lava flow formation.
Area 7:	The area is crisscrossed by steam pipelines and power lines on posts (not towers). It is close to the Masai Cultural Centre and in close proximity to Ol Njorowa Gorge (a significant tourist attraction)

(Source: Olkaria VII F.S. Team)

Table 1-3 Final criteria for the selection of Plant Site

Criteria	Site 1	Site 6	Site 7
Availability of flat space	3 –Slightly sloping terrain.	1 –Sloping and rugged terrain.	4 –Some flat terrain area, with gentle slope towards the gorges.
Space for future expansion	3 –There is nearby well pads, but yet enough area for expansion.	4 –Area has room for expansion.	3 –Area may fit 3 for expansion of 1 more plant although will have to avoid the nearby deep gullies.
Drainage - Catchment Area	2 –Has large catchment area from nearby hills. Existing natural drainage channels to be re-routed.	4 –very small catchment area with areas around sloping outwards.	3 The catchment area from nearby hills is not that big.
Access -through murram or tarmac road	4 –Plant area cuts through the tarmac road. Existing roads leading to nearby well pads can be used as diversion routes.	2 –A little off the usable murram road.	4 – Plant area cuts through the tarmac road, which will have to re-routed and upgraded.
Soil stability (erosion, land slide)	3 –Only slightly sloped and storm drains will sort out erosion.	3 –area sloppy but formation on rocky material thus stable.	3 –Area slightly slopy and storm drains will sort out erosion.
Cost for civil work: Earthworks, Retaining wall, Storm drains	3 –Earthworks not of big significance, mainly drainage works and some levelling works.	1 –Extensive earthworks to cut off rocky ridges and level up the quarried areas.	3 –Earthworks not of big significance, mainly drainage works.
Proximity to Geological Fault	3 –Since close to the Olkaria 1AU site, faults likelihood is not high. There is no direct superficial steaming.	1 –Likelihood of faults very high since earth surface steaming was observed at various places.	3 –Since close to Olkaria 1 site, likelihood of faults not high. There is no direct superficial earth steaming.

(Source: Olkaria-VII F.S. Team)

1.3.2. Generation Technology Appropriateness

Five power generation technologies (options 1 to Option 5 in Table 1-4 below) were evaluated in terms of resource characteristics, cooling system and eventual number of generation Units. Net output was found to be maximum if the single flash technology would be adopted for the new Power Plant.

Table 1-4 Generation Technologies and achievable Power Output

	Option 1	Option 2	Option 3	Option 4	Option 5
Generation technology	Single-flash cycle with condensing steam turbine	Single-flash cycle with condensing steam turbine	Single-flash condensing steam turbine	Combination of backpressure steam turbine and ORC	Two-phase binary
Number of units	1 STG	2 STG	1 STG	1 STG + 2 ORC	2 ORC
Cooling system	Wet cooling tower	Wet cooling tower	Hybrid cooling tower (dry section heat load 10%)	Air cooled condenser	Air cooled condenser
Gross output (MW)	80.30	80.30	80.30	60.78	64.58
Net output (MW)	**76.14**	**76.14**	**75.14**	**56.44**	**54.41**

(Source: Olkaria-VII F.S. Report)

In addition of having the highest net output, adopting the single-flash technology with condensing turbine and wet cooling tower resulted advantageous in terms of requiring the lowest CAPEX, and, in terms of achieving the lowest levelised cost of generated energy LCOE.

1.4. LOT 3: POWER EVACUATION SYSTEM

1.4.1. General cost considerations: Transmission Line.

The selected location of the Olkaria-VAU plant is very close to the Olkaria-IAU substation, that is, only about 800m from it in straight line to the southwest direction.

However, for the sake of avoiding the discharge of geothermal steam from existing well pads and, for avoiding crossing the path of other transmission lines existing in the area in between both plants, the route decided for the Transmission Line follows consolidated roads and forms an arced trajectory over a total length of approximately 2,700 meters. Refer to Figure 1-6.

The survey leading to above conceptual design was implemented by the Consultant of the Olkaria VII Feasibility Study in close coordination with KenGen technical personnel who specifically requested to avoid the abovementioned obstacles in addition storage areas and the mechanical shop of KenGen located close to the Olkaria-IAU power plant.

Although the resulting cost is obviously higher, since the transmission line route avoids a harmful zone and potential hazards, this route is regarded as adequate.



(Source: Study Team)

Figure 1-6 Transmission Line route from Olkaria VA to Olkaria-IAU substation

APPENDIX I-2

Project Comparison with Similar Projects in Olkaria

2. COMPARISON WITH SIMILAR PROJECTS IN OLKARIA

Table 3-2 summarises the main technical characteristics and the acquisition method implemented by KenGen for their Olkaria geothermal plants commissioned in the last ten year.

Table 3-2 KenGen Olkaria Plants general features

Olkaria Project name	Olkaria-I AU4&5	Olkaria-IV	Olkaria-I AU6	Olkaria-V	Olkaria VAU [1]
Year of EPC contract	2011	2011	2018	2017	2025
Year of COD	2014-2015	2014	2022	2019	2027
Generation technology	Single flash cycle, condensing steam turbine with direct contact condenser and forced draft counter-flow type wet cooling tower.				
Gross output	2 x 75.3MW	2 x 74.9 MW	1 x 86.9 MW	2 x 82.8 MW	1 x 80.3 MW
Steam flow	2 x 532 t/h	2 x 504 t/h	1 x 505 t/h	2 x 500 t/h	1 x 482.5 t/h
Steam pressure	5.0 bara	5.9 bara	9 bara	9 bara	9 bara
Procurement method	ICB	ICB	ICB	ICB	ICB
Contract type	EPC	EPC	EPC	EPC	EPC
PQ criteria (EPC)	International PQ	International PQ	International PQ	International PQ	International PQ
Warranty period	12 months	12 months	12 months	12 months	24 months

(Source: Study Team, West JEC data base)

Figure 3-1 in next page depicts KenGen's main geothermal power generation plants existing in Olkaria and currently in operation. In addition of the depicted plants, KenGen also owns Olkaria I, commissioned in the 80's and currently undergoing repowering works, in addition of a number of small geothermal wellhead plants scattered across the Olkaria field sectors.

[1] As per technical characteristics found in the Olkaria-VII F.S. and, KenGen's intention in regard the implementation of plant construction.



Olkaria-II [2]



Olkaria-IV (photograph: West JEC)



Olkaria-I Units 4&5 (photograph West JEC)



Olkaria-V [3]



Olkaria-IAU – Units 4, 5 and 6 -from left to right- (photograph: West JEC)

Figure 3-1 KenGen's geothermal power plants in Olkaria (except Olkaria-I)

[2] Source: https://www.kengen.co.ke/index.php/information-center/photo-gallery.html

[3] Source: Google Earth

APPENDIX I-3

LCPDP-recommended Generation Expansion Plan 2024 – 2031

3. LCPDP-RECOMMENDED GENERATION EXPANSION PLAN

Table 4-1 MoE Recommended Generation Expansion Plan for years 2024 - 2031

Year considered for system integration	Plant name	Type	Net capacity [MW]	Installed Effective [MW]
End of 2023				3,113
2024	KTDA Ltd, Lower Nyamindi	Small Hydro	0.8	
2024	KTDA - Nyambunde, Nyakwana	Small Hydro	0.5	
2024	KTDA Ltd, South Maara (Greater Meru Power Co.)	Small Hydro	1.5	
2024	KTDA Ltd, Iraru	Small Hydro	1.0	
2024	Marco Borero Co Ltd.	PV	1.5	
2024	REA Vipingo Plantations Ltd (DWA Estates Ltd)	Biomass	1.44	
End of 2024			6.74	3,120
2025	Mt Kenya Community Based Organisation	Small Hydro	0.6	
2025	Tindinyo Falls Resort	Small Hydro	2.4	
2025	Kleen Energy Limited	Small Hydro	6	
5	Kaptagat Solar Park (Tarita Green)	PV+BESS	40	
2025	Menengai 1 Phase I - Stage 1 (Quantum)	Geothermal	35	
2025	Menengai 1 Phase I - Stage 1 (Orpower22)	Geothermal	35	
2025	Wellhead leasing	Geothermal	58.64	
2025	Imenti Factory Limited	Small Hydro	-0.3	
End of 2025			**177.3**	3,297
2026	Olkaria IV Uprating	Geothermal	20	
2026	HVDC Ethiopia2	Import	100	
2026	HVDC Ethiopia3	Import	100	
2026	Olkaria 1 AU 4 & 5	Geothermal	20	
2026	Olkaria 1 - Unit 1 Rehabilitation	Geothermal	21	
2026	Olkaria 1 - Unit 2 Rehabilitation	Geothermal	21	
2026	Olkaria 1 - Unit 3 Rehabilitation	Geothermal	21	
2026	KTDA Chemosit	Small Hydro	0.25	
2026	Frontier Investment/ Nithy Hydro	Small Hydro	5.6	
2026	Gem Gen Power Company Ltd.	Small Hydro	9.5	
2026	Prunus	Wind+BESS	50	
2026	Chania Green	Wind +BESS	50	
2026	Aperture	Wind+ BESS	50	
2026	Kopere Solar Park Limited	PV+BESS	40	
2026	BESS_1	BESS	100	
2026	BESS_3	BESS	50	
2026	Power Technologies (Gatiki Small Hydro Plant)	Small Hydro	9.6	
2026	Gogo upgrade	Small Hydro	8.6	
2026	Gogo Existing small hydro	Small Hydro	-2	
End of 2026			**674.6**	3,972

Source: LCPDP 2024-2043, MoE Kenya

Year considered for system integration	Plant name	Type	Net capacity [MW]	Installed Effective [MW]
2027	Baringo Silali - Paka I	Geothermal	100	
2027	Olkaria II Extension (Olkaria 6)	Geothermal	140	
2027	Olkaria 7	Geothermal	80	
2027	KTDA, Kipsonoi (Settet Power Co.)	Small Hydro	0.6	
2027	Kenergy Renewables Ltd- Rumuruti	PV+BESS	40	
2027	Kibwezi One Energy Limited	PV+BESS	40	
2027	Hannan Arya Energy (K) Ltd	PV+BESS	10	
2027	Seven Forks (Kamburu) Solar Power Plant	PV	**42.5**	
2027	Kwale Int. Sugar Co. Ltd	Biomass	10	
2027	Tana Biomass Generation Ltd (Biogas-Solar Hybrid)	Biomass	20	
2027	Ngong 1, Phase I	Wind	-5.1	
End of 2027			**478.0**	4,450
2028	Reike Ltd (Kaiuthi SHPP-Sagana I)	Small Hydro	20	
2028	BESS_2	BESS	100	
2028	Isiolo Power (Greenmillenia Energy) Limited	PV+BESS	40	
2028	Raising Masinga	Hydropower	-	
2028	Ngong 1 - Phase III	Wind	11	
2028	Ol-Danyat Energy	Wind+BESS	30	
2028	Electrawinds Bahari	Wind+BESS	50	
2028	Thika Way Investments (Homa Bay Biogas One)	Biomass	8	
2028	KenGen Olkaria Wellheads I	Geothermal	**-44.6**	
End of 2028			**214.4**	4,664
2029	Baringo Silali - Silali I	Geothermal	100	
2029	UETCL Import2	Import	150	
2029	Reike Ltd (Ithanji SHPP-Sagana II)	Small Hydro	20	
2029	Marsabit Phase I - KenGen	Wind+BESS	100	
2029	Global Sustainable-Kaptis	Small Hydro	**14.7**	
2029	Global Sustainable Ltd-Buchangu	Small Hydro	4.5	
2029	Mutunguru Hydroelectric Company Ltd	Small Hydro	7.8	
2029	Khalala Hydro Power Kenya Ltd. (Coastal Energy Ltd)	Small Hydro	20	
2029	Ventus Energy Ltd	Small Hydro	7.7	
2029	Menengai III	Geothermal	100	
2029	Olkaria 2	Geothermal	-101	
End of 2029			**423.7**	5,088
2030	BESS_4	BESS	50	
2030	Makindu solar ltd	PV+BESS	30	
2030	Greenlight Holdings/ Rianjue/Gichuki Ventures	Small Hydro	1.5	
2030	Pumped hydro storage - Unit 1	Pumped storage	300	
2030	Kenya Solar Energy	PV+BESS	40	
2030	Mwikhupo-Mwibale Hydro Power Kenya	Small Hydro	7	
2030	Virunga Power Holdings Ltd, R. Sossio, Kaptama	Small Hydro	4.5	
2030	Njega/Rukenya Hydro Power Ltd. (Rights transfer)	Small Hydro	3.5	
2030	Western Hydro	Small Hydro	10	
2030	Kibisi Kinetic Energy Ltd.Virunga Power Holdings	Small Hydro	6.5	
2030	Kirogori Electrification Project	Small Hydro	7	
2030	KTDA R. Chemosit, Chemosit	Small Hydro	2.5	
2030	Rareh Nyamindi Hydro Ltd- Mbiri	Small Hydro	5.2	
2030	Rareh Nyamindi Hydro Ltd- Kiamutugu	Small Hydro	9.4	
2030	Rareh Nyamindi Hydro Ltd-Gitie	Small Hydro	6	

Year considered for system integration	Plant name	Type	Net capacity [MW]	Installed Effective [MW]
2030	VSHydro Kenya Ltd	Small Hydro	9.1	
2030	Roadtech Solutions Ltd	Biomass	10	
End of 2030			**502.2**	5,590
2031	High Grand Falls Stage 1+2	Hydropower	693	
2031	Karuga Gitugi Electrification Project	Small Hydro	2.7	
2031	KTDA Chemosit, Kiptiget	Small Hydro	3.3	
2031	KTDA Ltd, Yurith, Chemosit	Small Hydro	0.9	
2031	KTDA R. Rupingazi, Rutune	Small Hydro	1.8	
2031	KTDA, R. Itare, Chemosit	Small Hydro	1.3	
2031	KTDA, R. Yala, Taunet	Small Hydro	2.8	
2031	Tridax Limited	Small Hydro	4.2	
2031	Truck city ltd	Small Hydro	5.3	
2031	Rabai Diesel (CC-ICE)	Diesel engines	**-88.6**	
End of 2031			**626.7**	6,217
2032	Karura	Hydropower	90	
2032	Eburru 2	Geothermal	25	
2032	Chevron Africa Limited	Small Hydro	7.8	
2032	Dominion Farms	Small Hydro	1	
2032	Webuye Falls-KenGen	Small Hydro	40	
2032	Viability Africa (Northern Energy Limited)	Biomass	2.4	
2032	Cummins Cogeneration Kenya Limited	Biomass	8.4	
2032	Baringo Silali Paka II	Geothermal	100	
2032	Suswa I	Geothermal	100	
2032	Electrawinds Bahari Phase 2	Wind+BESS	40	
2032	Meru Phase 1	Wind+BESS	80	
2032	BESS_5	BESS	150	
2032	Kipevu 3	Diesel engines	-115	
2032	KenGen Olkaria Wellheads II & Eburru	Geothermal	**-27.5**	
End of 2032			**502.1**	6,719
2033	Olkaria II Rehabilitation	Geothermal	105	
2033	Olkaria 8	Geothermal	140	
2033	Menengai I Stage II	Geothermal	60	
2033	Njumbi Hydropower Plant Ltd (Hydroneo)	SmallHydro	9.6	
2033	Hydel	Small Hydro	5	
2033	VR Holding AB-Local Trade Ltd	Biomass	3	
End of 2033			**322.6**	7,041
2034	Nuclear Unit 1	Nuclear	**291.3**	
2034	Meru Phase II	Wind+BESS	100	
2034	Generic small hydro	Small Hydro	22	
2034	West Kenya Sugar Company Limited	Biomass	6	
2034	Biogas Holdings Ltd	Biogas	0.3	
2034	Generic PV	PV+BESS	40	
End of 2034			**459.6**	7,501
2035	Menengai IV	Geothermal	100	
2035	Baringo Silali - Korosi /Chepchuk I	Geothermal	100	
2035	AGIL Longonot Stage 1	Geothermal	35	
2035	AGIL Longonot Stage 2	Geothermal	35	
2035	AGIL Longonot Stage 3	Geothermal	35	
2035	Marsabit Phase II - KenGen	Wind+BESS	200	

APPENDIX I-4

KenGen's Risk profile and Mitigation Policy

4. KENGEN'S RISK PROFILE AND MITIGATION POLICY

Table 5-1 KenGen Risk Profile and Mitigation Policy

NO.	RISK	RISK DESCRIPTION	MITIGATION MEASURES
1.	Globalization Risk (global economic downturn, inflationary and foreign exchange pressures)	KenGen's business environment is interdependent on regional and international markets, making it vulnerable to global disruptions that add pressure to an already challenging macro-economic situation.	Continuously monitoring global macro-economic factors and strengthening our strategic advocacy to influence policies that support KenGen's business. This approach keeps us informed and adaptable to emerging economic changes.
2.	**Market Risk**	The evolving electricity sector, with open access and regional integration, may reduce our market share due to increased competition from Independent Power Producers (IPPs) and regional players offering competitive prices.	Implementing and operationalizing regulations for the Electricity Market, Bulk Supply, and Open Access, while strategically advocating for the development of regulatory and institutional frameworks that affect our business. These actions have been crucial in creating a supportive and effective regulatory environment for the company.
3.	**Counter Party Risks**	Diversification may lead to more counter parties, increasing credit risk and the potential for commercial disputes and litigations, which could negatively impact KenGen's cash flow and revenues.	Developed strategies for guarantees, advance payments, and debt recovery to reduce receivable days, secured government approvals, and are continuously managing contingent liabilities.
4.	**Stakeholder Management Risk**	KenGen's diverse stakeholders, including government agencies, financiers, communities, shareholders, and the public, have competing interests that could hinder the achievement of our strategy.	KenGen has established a robust stakeholder collaboration framework that is continuously monitored and refined to ensure the needs and expectations of all stakeholders are effectively met.

NO.	RISK	RISK DESCRIPTION	MITIGATION MEASURES
5.	**Cyber Security risks**	KenGen's digital transformation introduces cybersecurity risks due to increased reliance on technology and modern work methods, exposing ICT systems to potential cyber-attacks, unauthorized access, data loss, and business interruptions.	Continuously reviewing our security measures and performing regular checks on the company's ICT systems for vulnerabilities, such as penetration testing and vulnerability assessments, while integrating staff awareness into these practices to ensure a secure ICT environment.
6.	**Project Execution & Financing risk**	Project execution risks involve cost, time, and scope variations that can cause delays, quality issues, and cost overruns, while project financing risks could arise from the high value of KenGen's projects, which may exceed the balance sheet's ability to support required loans.	Optimized contract and project management processes by conducting root cause analysis, and applying lessons learned through multi-disciplinary teams. We also manage revenue leakages, optimize expenses to boost profitability and equity, and explore innovative financing options like Private Equity, Private Public Partnerships (PPPs), and Special Purpose Vehicles (SPVs).
7.	**Generation Resource Sustainability (steam decline & hydrology) Risk**	Unfavourable hydrological conditions, potential depletion of geothermal resource, and fossil fuel supply disruptions could negatively impact current generation and future capacity expansion.	Adopted new technologies and reservoir management initiatives, such as steam reinjection, and are advocating for more geothermal field allocations. We have also formed partnerships and joint ventures to support resource development while managing climate change risks and collaborating on resource conservation.

Source: Integrated Annual Report & Financial Statements for the Year Ending 30 June 2024, KENGEN

NO.	RISK	RISK DESCRIPTION	MITIGATION MEASURES
8.	**Legal & Regulatory Risk**	Changes in regulations and uncertainty in obtaining geothermal project licenses pose compliance risks for KenGen and may hinder growth. Additionally, changes in PPA structures could affect the recovery of capital investments.	Continuously engaging with key government and energy sector entities to secure licenses, land, and resources, while ensuring energy PPAs are cost-reflective and include payment for deemed energy.
9.	**Single Revenue Stream Risk**	KenGen relies on the primary off-taker for about 96% of its revenues, making it vulnerable to the off-taker's financial status.	Adopted a comprehensive diversification policy to seize profitable opportunities, which has facilitated the launch of several diversification projects. We anticipate these initiatives will generate substantial revenues and drive significant growth.
10.	**Leadership & Governance Risk**	Deviation from good corporate governance can damage KenGen's reputation, lead to asset misappropriation, and harm corporate performance. As a listed company, negative publicity related to governance and ethics could also decrease the market share price.	Continuously monitoring adherence to the Capital Markets Authority (CMA) Code of Governance, Mwongozo Code, and company policies, strengthening corporate governance through 360 board appraisals, annual board evaluations and independent audits, and act on recommendations. KenGen has also established a robust succession planning mechanism across all levels for business continuity.

Source: Integrated Annual Report & Financial Statements for the Year Ending 30 June 2024, KENGEN

ANNEX-II

GRID CONNECTION STABILITY STUDY

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List of Acronyms and Abbreviations

ABBREVIATION	DESCRIPTION
Amps	Ampere
AU	Additional Unit
CCT	Critical clearing time
CKT	Circuit
COD	Commercial Operation Date
kA	kiloampere
km	kilometre
kV	kilovolt
LCPDP	Least cost power development plan
MVA	Megavolt-amperes
MW	Megawatt
p.u	Per Unit
Pgen	Generator power output
Pmax	Max power
Pmin	Minimum power
PSSE	Power System Simulation for Engineering
Qma	Maximum reactive power output
Qmin	Minimum reactive power output
SCR	Short Circuit Ratio
V	Volt
Vpu	Per unit voltage
Vsc	Scheduled Voltage

EXECUTIVE SUMMARY

This study comprises of the required power system analysis, to determine compliance with Kenyan Grid Code and to assess the grid capacity for integration of the proposed Olkaria V-AU, 80.3 MW power plant in 2027 at Olkaria geothermal complex. It also reports on contingency analysis performance of the national grid in 2027 and thereafter at a period of 5 years and 10 years, in 2032 and 2037, respectively. The analysis is based on the power system expansion in accordance with the Kenya Least Cost Power Development Plan in 2024-2043.

Load flow calculation is the basic power system analysis that determines the power flows in all the system lines and equipment, and voltages and their phase angles at all system grid nodes given the system loads and power generation outputs. The results of load flow include loadings and voltage profiles of lines and equipment in comparison with their respective ratings. The contingency analysis is used to assess the load flow conditions on the system in the event of a line or equipment outage. In this study, load flow and contingency analysis were carried out for 2027, when the proposed power plant is connected to the grid and thereafter 2032 and 2037. The resulting conclusions are summarized hereunder:

Based on load flow analysis results, it is concluded as follows:

a. Connection of the power plant in 2027 increases network loading resulting to marginal overloading of Olkaria 1U -Naivasha 132 kV line (102.5%) at system peak. Other lines transmitting power from Olkaria to Nairobi including Suswa -Nairobi North 220 kV lines and Naivasha – Ruaraka are also expected to be highly loaded (above 80% at system peak) in all cases. Network loading following connection of the power plant is worst in 2027 as the Gilgil-Thika leg of the planned Nairobi 400 kV transmission ring will not have been commissioned.
b. The proposed power plant does not result in grid voltage violations. In all cases bus voltages in Olkaria region are expected to lie between 1.00 p.u. and 1.03 p.u.

Based on contingency analysis results the following conclusions are made:

a. Connection of the power plant in the year 2027 and operation in years 2032 and 2037 will not result to single contingency overloads under both peak and off-peak load conditions in Olkaria region considering short term contingency rating as 110% of continuous rating.
b. However, in 2027 Olkaria 1AU -Naivasha 132 kV line is expected to be slightly overloaded (102.5%).

Apart from Load Flow and Contingency Analysis, stability study is carried out to assess the system suitability. A power system is considered unstable if at least one generator unit goes out of synchronism following a large disturbance (such as three--phase line short circuit). The results of analysis undertaken for Kenyan grid in year 2027, is summarized below:

a. Transient stability is established for all the disturbances simulated. In all cases, following disturbance machine rotor angles exhibit well dumped oscillations that die out within 3-4 seconds. Bus voltages and frequency recover to near the steady state values within 3 seconds. The different machines swing in the same direction indicating no loss of synchronism.
b. Three--phase short circuit fault disturbances result in the most significant rotor angle oscillations and frequency deviation compared to loss of generation disturbances. The worst-case frequency deviation (0.006 p.u. or 0.3 Hz) occurs in the case of three--phase fault and trip of one of the Suswa-Nairobi North 220 kV lines
c. A sustained fault on the transmission line evacuating the new power plant cleared in 175ms does not result in loss of synchronism for the new generator. Rotor angle and frequency oscillations die out within 4 seconds, and voltage recovers to initial value within 3 seconds. The generator active and reactive power output stabilizes within 4 seconds and recovers to pre disturbance values within 10 seconds

OLKARIA-VAU GRID POWER EVACUATION STUDY

NETWORK ANALYSIS

1 PREAMBLE

This study comprises of the required power system analysis to assess the grid capacity for integration of the proposed 80.3MW power plant in the Olkaria region of the Kenyan grid. The Study assumes power grid conditions matching those for December 2027, month of the scheduled Commercial Operation Date of the power plant, as are planned in detail in the latest Kenya's Least Cost Power Development Plan [1].

2 KEY ASSUMPTIONS

In carrying out the analysis the following is assumed:

(i) The plant commercial operation date (COD) is December 2027.

(ii) The power plant will be configured as one unit of 80.3 MW (1x80.3 MW).

(iii) Power demand and grid development will follow the existing last Kenyan Least Cost Power Development Plan. That is, the following key transmission projects in Olkaria generation complex and environs that would have been completed and integrated into the grid by December 2027:

- Olkaria-IAU – Olkaria-V 220 kV double circuit line.
- Gilgil 400/220 kV substation.
- Gilgil – Maralal Loiyangalani 400 kV line and Maralal-Baringo – Lessos 400 kV line (conversion of Suswa -Loiyangalani line from 220 kV to 400 kV operation).
- Suswa-Kimuka -Isinya double circuit 400 kV line (conversion of 2nd circuit from 220 kV to 400 kV operation).
- Installation of phase shift transformers on Suswa-Nairobi North 220 kV lines at Suswa 220 kV substation.

(iv) Unless otherwise specified in the LCPD and other provided data, grid modelling and provided PSSE model update will assume similar transmission lines, generators and other power system equipment parameters as applied in the provided PSSE grid models.

(v) 140 MW Olkaria II Extension power plant which will be developed in the same region will have been completed and integrated to the grid at Olkaria-II 220 kV substation.

(vi) Whereas the power system analysis will be based on the entire Kenya grid, assessment of grid capacity will focus on Olkaria region and environs only and assume the grid operator will take the necessary action to build the necessary grid capacity in the rest of the grid. Such requirements will be pointed out in this report to the extent that they impact on the integration of the power plant.

(vii) In assessing the grid capacity, the analysis will consider the two extreme grid conditions, the peak load when the grid is expected to be most stressed and the off-peak loading when grid voltage is expected to be highest and, therefore, requiring adequate management.

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[1] Least Cost Power Development Plan – LCPDP – 2024-2043; Ministry of Energy, MoE; June 2024.

3 LOAD FLOW ANALYSIS

3.1 Introduction

The load flow calculation is the basic analysis on a power system for determining the power flow in all the system lines and equipment. In addition, it determines voltages and their phase angles at all system grid nodes for the given system power generation outputs and loads. It is a non-linear problem which through iterative methods determines values of the unknown variables to achieve convergence of power flow solution with negligible active and reactive power mismatch. The power flow problem pertains to balanced steady-state operation of the power system. As it considers balanced operation in which all negative and zero sequence voltages are zero, the power flow calculation deals with the positive-sequence model of all power system components.

The key inputs for load flow analysis include:

(i) Real power output of each generator
(ii) Transmission line impedances and charging admittances
(iii) Transformer impedances, tap ratios and voltage control logic
(iv) Load at each of the system load nodes
(v) Voltage magnitude at each generator node
(vi) Maximum and minimum reactive power output capability of each generating plant.

The key objective of load flow analysis in grid connection studies is to establish the capacity of the transmission grid to evacuate from new power plant and determine technically feasible and cost-effective methods of connecting the power plant without significant negative impact on the grid. These include transmission equipment overloading, grid voltage violations and excessive power losses.

3.2 Methodology

Load flow analysis was carried out in PSSE software tool. The calculation was based on the projected 2027 Kenya grid model (Base Case) developed on the basis of the Least Cost Power Development Plan (LCPDP) 2024 -2043 provided by the client at both system peak and off-peak conditions. The procedure outlined below was followed in developing the 2027 Base Case PSSE model and the proposed Olkaria V AU power plant grid connection study models.

3.2.1 Development of the 2027, 2032 and 2037 PSSE models

Starting with the year 2025 model provided, the year 2027 PSSE model was developed through update of 2025 model data with transmission lines, transformers, generators and load data as detailed in the LCPDP 2024-2043 report provided by the client. The developed model constituted the 2027 power system load flow model (Base Case model) for the proposed Olkaria V AU power plant grid connection steady state studies. Similarly, years 2032 and 2037 PSSE models were developed from the provided years 2035 and 2040 Kenya grid PSSE planning models through removal of the modelled grid equipment data following the provisions of the LCPDP.

3.2.2 Modelling the proposed Olkaria V AU power plant

The generator units, step up transformers and interconnecting lines were modelled in the 2027 Base case model and modelled details conformed in years 2032 and 20 37 PSSE grid models.

The equipment modelling details were as follows:

Generators

In modelling for load flow studies, the generators were modelled as voltage sources i.e., constant voltage and constant power sources. The following generator data /parameters were applied:

MVA rating, Maximum output (MW), Minimum output (MW), Voltage rating, operating power factor limits (Leading and lagging) and Source impedance (R" and X''). Based on these parameters, the following data will be modelled for each of the generators; Base MVA (Rated MVA), Power Output (Pgen), Voltage (V), Max output (Pmax), Minimum output (Pmin.), Maximum reactive power output (Qmax), Minimum reactive power output (Qmin.), Source impedance (R source and X source) and scheduled Voltage (Vsc).

Transformers

In modelling for load flow studies, the following key transformer data was applied; The rated capacity (MVA), Vector group, impedances (R p.u. and X p.u.), Windings rated voltage (kV), off nominal turns ratio, control data; controlled bus, no. of tap positions, control mode, voltage control range.

Transmission lines

For transmission lines modelling the input data included line lengths, series impedances (Rp.u. and Xp.u.), capacitive admittances/ line charging (Bp.u), shunt admittances (G and B p.u.) and ratings in MVA.

3.3 GRID LOAD FLOW SIMULATION AND ANALYSIS

The objective of load flow simulations for this study was to confirm the technical feasibility of evacuating the proposed 80.3 MW Olkaria V AU power generation. Therefore, upon development of the 2027 Base case model and modelling the new power plant in PSSE tool, the Kenya grid simulation and Load flow studies were carried out for the 2027 Base case without and with the proposed Olkaria V AU power plant. This study assumes the power plant will be connected at Olkaria IAU 220 kV substation through construction of approximately 2.7km double circuit 220 kV line in canary conductor.

To confirm adequacy of the future planned grid for the operation of the proposed power plant, grid simulation and load flow studies were repeated for the planned 2032 and 2037 Kenya grid.

In each of the cases of load flow, load flow analysis was carried out to determine:

(i) Network loading and overloading if any
(ii) Voltage violations based on grid code requirements
(iii) Comparative power flows and network losses

3.4 Dispatch for Interconnected Generators

The key objective of this study is to establish the capacity of the Olkaria region transmission network to evacuate the new power plant in addition to the existing power plants in the region. Therefore, the grid dispatch assumption is that all power plants in Olkaria region, including Lake Turkana wind farm and Ethiopia imports, which are evacuated at Suswa substation are dispatched at full capacity. Consequently, to maintain power balance, thermal dispatch as well as dispatch from hydro power plants with storage reservoirs was reduced as required. The grid power dispatch list for the Base Case in year 2027 is added herewith at the end of this Report as Attachment I.

3.5 LOAD FLOW ANALYSIS RESULTS

This section outlines results of lines and equipment overloading, highly loaded lines and equipment, voltage violations and power flows in Olkaria region grid as well as comparative analysis of network losses associated with each of the alternative connection options.

3.5.1 Lines and Equipment Loading

i. BASE CASE 2027

(a) SYSTEM PEAK

(i) OVERLOADED TRANSMISSION LINES

2027 BASE CASE

SUBSYSTEM LOADING CHECK: LOADINGS ABOVE 100.0 % OF LINE RATING:

X--------- FROM BUS ----------X---------- TO BUS ----------X RATING SET A
BUS# X-- NAME --X BASKV AREA BUS# X-- NAME --X BASKV AREA CKT LOADING RATING PERCENT

* NONE *

(ii) HIGHLY LOADED TRANSMISSION LINES ABOVE 60% OF LOADING

TRANSMISSION LINE		VOLTAGE		LINE LOADING		
FROM	TO		CKT	MVA	RATING (MVA)	% LOADING
SUSWA	NRB NORTH	220	1	268.7	274	98.1
SUSWA	NRB NORTH	220	2	268.7	274	98.1
OLKARIA-IAU	NAIVASHA	132	1	182.3	190	95.9
MAHI MAHIU	NAIVASHA	132	1	78	89.2	87.5
MAHI MAHIU	NAIVASHA	132	2	78	89.2	87.5
OLKARIA-II	OLKARIA-IAU	132	1	138.6	165	84
RUARAKA	MAHI MAHIU	132	2	74.7	89.2	83.8
RUARAKA	MAHI MAHIU	132	1	74.7	89.2	83.8

ii.

(b) SYSTEM OFF-PEAK

(i) OVERLOADED TRANSMISSION LINES

2027 BASE CASE OFF-PEAK

SUBSYSTEM LOADING CHECK: CURRENT LOADINGS ABOVE 100.0 % OF LINE RATING:

X--------- FROM BUS ----------X X---------- TO BUS ----------X RATING SET A
BUS# X-- NAME --X BASKV AREA BUS# X-- NAME --X BASKV AREA CKT LOADING RATING PERCENT

* NONE *

(ii) HIGHLY LOADED TRANSMISSION LINES ABOVE 60% OF LOADING

TRANSMISSION LINE		VOLTAGE	CKT	LOADING		
FROM	TO			MW	RATING(MW)	% LOADING
SUSWA	NRB NORTH	220	1	200.8	274	73.3
SUSWA	NRB NORTH	220	2	200.8	274	73.3
DANDORA	EMBAKASI	220	1	199.9	274	73
NRB NORTH	THIKA RD	220	1	169.9	274	62
NRB NORTH	THIKA RD	220	2	169.9	274	62

2027 Olkaria V AU Grid connection

(a) SYSTEM PEAK

(i) OVERLOADED LINES AND EQUIPMENT

2027 OLKARIA V AU PEAK

SUBSYSTEM LOADING CHECK: CURRENT LOADINGS ABOVE 100 % OF LINE RATING:

TRANSMISSION LINE		VOLTAGE	CKT	LOADING		
FROM	TO	kV		MW	RATING (MW)	% LOADING
K_NAIVASHA-II	K_OLKARIA-IAU	132	1	194.7	190	102.5

(ii) HIGHLY LOADED LINES AND EQUIPMENT

2027 OLKARIA V AU PEAK

SUBSYSTEM LOADING CHECK: LOADINGS ABOVE 60% OF RATING

TRANSMISSION LINE		VOLTAGE	CKT	LOADING		
FROM	TO	kV		MW	RATING (MW)	%LOADING
MAHI MAHIU	RUARAKA	132	2	80.9	89.2	90.7
MAHI MAHIU	RUARAKA	132	1	80.9	89.2	90.7
NAIVASHA	MAHI MAHIU	132	1	84.2	89.2	94.3
NAIVASHA	MAHI MAHIU	132	2	84.2	89.2	94.3
SUSWA	NAIROBI NORTH	220	1	270.7	274	98.8
SUSWA	NAIROBI NORTH	220	2	270.7	274	98.8
OLKARIA-I	OLKARIA-IAU	132	1	146.6	165	88.8
OLKARIA-IAU	NAIVASHA	132	1	194.7	190	102.5

(b) SYSTEM OFF-PEAK

(i) OVERLOADED LINES AND EQUIPMENT

2027 OLKARIA-VAU OFF PEAK

SUBSYSTEM LOADING CHECK: CURRENT LOADINGS ABOVE 100.0 % OF LINE RATING:

X--------- FROM BUS ----------X, X---------- TO BUS ----------X RATING SET A
BUS# X-- NAME --X BASKV AREA BUS# X-- NAME --X BASKV AREA CKT LOADING RATING PERCENT

* NONE *

(ii) HIGHLY LOADED LINES AND EQUIPMENT ABOVE 60% OF RATING

TRANSMISSION LINE		VOLTAGE	CKT	LOADING		
FROM	TO	kV		MVA	RATING (MVA)	%
SUSWA	NAIROBI NORTH	220	1	206.3	274	75.3
SUSWA	NAIROBI NORTH	220	2	206.3	274	75.3
DANDORA	EMBAKASI	220	1	196	274	71.5
NAIROBI NORTH	THIKA ROAD	220	1	175.4	274	64
NAIROBI NORTH	THIKA ROAD	220	2	175.4	274	64
THIKA ROAD	DANDORA	220	1	166.6	274	60.8
THIKA ROAD	DANDORA	220	2	166.6	274	60.8

2032 Olkaria V AU Grid operation

(a) SYSTEM PEAK

(i) OVERLOADED LINES AND EQUIPMENT

2032 OLKARIA V AU PEAK OPERATION

SUBSYSTEM LOADING CHECK: CURRENT LOADINGS ABOVE 100.0 % OF RATING:

X--------- FROM BUS ----------X, X---------- TO BUS ----------X RATING SET A
BUS# X-- NAME --X BASKV AREA BUS# X-- NAME --X BASKV AREA CKT LOADING RATING PERCENT

* NONE *

(ii) HIGHLY LOADED LINES AND EQUIPMENT ABOVE 60% OF RATING

2032 OLKARIA-VAU PEAK OPERATION

TRANSMISSION LINE		VOLTAGE	CKT	LOADING		
FROM	TO	kV		MVA	RATING (MVA)	%
SUSWA	NAIROBI NORTH	220	2	261.6	274	95.5
SUSWA	NAIROBI NORTH	220	1	261.6	274	95.5
OLKARIA-IAU	NAIVASHA	132	1	171.4	190	90.2
OLKARIA-1	OLKARIA-IAU	132	1	135.7	165	82.2
JUJA ROAD	RUARAKA	132	1	71.3	89	80.1
JUJA ROAD	RUARAKA	132	2	71.3	89	80.1

(b) SYSTEM OFF PEAK

(i) OVERLOADED TRANSMISSION EQUIPMENT

2032 OLKARIA-VAU OFF PEAK OPERATION

SUBSYSTEM LOADING CHECK: CURRENT LOADINGS ABOVE 100.0 % OF RATING:

X--------- FROM BUS ----------X, X---------- TO BUS ----------X RATING SET A
BUS# X-- NAME --X BASKV AREA BUS# X-- NAME --X BASKV AREA CKT LOADING RATING PERCENT

* NONE *

(ii) HIGHLY LOADED TRANSMISSION EQUIPMENT ABOVE 60% OF RATING

2032 OLKARIA V AU OFF PEAK OPERATION

TRANSMISSION LINE		VOLTAGE	CCT	LOADING		
FROM	TO	kV		MVA	RATING (MVA)	%
SUSWA	NAIROBI NORTH	220	1	212.8	274	77.7
SUSWA	NAIROBI NORTH	220	2	212.8	274	77.7

iii. 2037 OLKARIA-VAU GRID OPERATION

(a) SYSTEM PEAK

(i) OVERLOADED LINES AND EQUIPMENT

2037 OLKARIA-VAU PEAK OPERATION

SUBSYSTEM LOADING CHECK: CURRENT LOADINGS ABOVE 100.0 % OF RATING:

X--------- FROM BUS ----------X, X---------- TO BUS ----------X RATING SET A
BUS# X-- NAME --X BASKV AREA BUS# X-- NAME --X BASKV AREA CKT LOADING RATING PERCENT

* NONE *

(ii) HIGHLY LOADED LINES AND EQUIPMENT ABOVE 60% OF RATING

2037 OLKARIA VAU PEAK OPERATION

TRANSMISSION LINE		VOLTAGE	CKT	LOADING		
FROM	TO	kV		MVA	RATING (MVA)	%
OLKARIA-IAU	NAIVASHA	132	1	185.4	190	97.6
SUSWA	NAIROBI NORTH	220	1	242.9	274	88.6
SUSWA	NAIROBI NORTH	220	2	242.9	274	88.6
NAIVASHA	MAHI MAHIU	132	1	77.4	89.2	86.8
NAIVASHA	MAHI MAHIU	132	2	77.4	89.2	86.8
OLKARIA-I	OLKARIA-II	132	1	111.1	135	82.3
OLKARIA-I	OLKARIA-IAU	132	1	133.8	165	81.1

Summary of Key transmission lines loading

(a) SYSTEM PEAK

Table 1 below is a summary of expected key transmission lines loading in Olkaria region for year 2027 Base case, 2027 connection and during operation in 2032 and 2037.

Table 1: Key transmission lines loading at system peak

	Base Case 2027		2027 Connection		2032 Operation		2037 Operation	
Transmission Line	**MVA**	**%**	**MVA**	**%**	**MVA**	**%**	**MVA**	**%**
Olkaria II –Suswa 220kV	94.3	33.3	101.3	35.9	95.4	34.5	84.9	30.7
Olkaria II – Lessos 220 kV	53	5.7	59.8	6.5	91.9	10.1	95.6	10.5
Olkaria IAU –Suswa 220kV	113.5	40.1	124.1	44	124	44.7	108.5	39.1
Olkaria IV –Suswa 220kV	141	49.8	149.4	53	167.8	60.4	144.3	51.9
Olkaria IAU – OLKARIA II 220kV	6.5	2.3	22.6	6	81.5	29.4	52.9	19
Olkaria V – Olkaria IAU	22.3	7.9	13.6	4.8	72.8	26.3	54.4	19.6
Olkaria V – Olkaria IV	64.1	19	72.3	21.5	88.7	26.8	65.2	19.7
Olkaria II EXT – Olkaria II	146.2	51.6	145.2	51.4	147.3	47.8	131.3	42.5
Suswa-Nairobi North 220 kV	271.4	98.1	272.6	98.8	271.9	95.5	254.5	94.5
Suswa – Kimuka 400 kV	468.4	27.8	484.5	28.8	420.5	25.7	379.7	23
Suswa-Gilgil 400 kV	89.3	5.4	83.8	5.2	54.5	3.3	92	5.5
Gilgil – Thika 400 kV					153.2	9.3	254.7	15.3
Olkaria-II – Olkaria I 132 kV	97.9	70.2	107	76.9	74.5	54.3	111	81.2
Olkaria-I – Olkaria IAU 132 kV	143.1	84	151	88.8	137.7	82.2	134.1	80.3
Olkaria IAU – Naivasha 132 kV	188.1	95.9	200.5	102.5	173.8	90.2	185.4	96.5

Bus Voltage Violations Check

Olkaria region transmission system load flow simulation indicates on connection and subsequent operation of the proposed power plant, grid voltage limits will remain within the requirements of the Kenya grid code. The following are the PSSE analysis results for the Base case, with connection of the power plant in 2027 and during future power plant operation in 2032 and 2037.

BASE CASE 2027

(a) SYSTEM PEAK

2027 BASE CASE PEAK

BUSES WITH VOLTAGE GREATER THAN 1.0500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

BUSES WITH VOLTAGE LESS THAN 0.9500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

(b) SYSTEM OFF –PEAK

2027 BASE CASE OFF PEAK

BUSES WITH VOLTAGE GREATER THAN 1.0500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

BUSES WITH VOLTAGE LESS THAN 0.9500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

2027 OLKARIA-VAU GRID CONNECTION

(a) SYSTEM PEAK

2027 GRID CONNECTION PEAK

BUSES WITH VOLTAGE GREATER THAN 1.0500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

BUSES WITH VOLTAGE LESS THAN 0.9500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

(b) SYSTEM OFF –PEAK

2027 GRID CONNECTION OFF PEAK

BUSES WITH VOLTAGE GREATER THAN 1.0500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

BUSES WITH VOLTAGE LESS THAN 0.9500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

2032 OLKARIA-VAU GRID OPERATION

(a) SYSTEM PEAK

2032 GRID OPERATION PEAK

BUSES WITH VOLTAGE GREATER THAN 1.0500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

BUSES WITH VOLTAGE LESS THAN 0.9500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

(b) SYSTEM OFF –PEAK

2032 GRID OPERATION OFF PEAK

BUSES WITH VOLTAGE GREATER THAN 1.0500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

BUSES WITH VOLTAGE LESS THAN 0.9500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE

2037 OLKARIA-VAU GRID OPERATION

(a) SYSTEM PEAK

2032 GRID OPERATION PEAK

BUSES WITH VOLTAGE GREATER THAN 1.0500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

BUSES WITH VOLTAGE LESS THAN 0.9500:

BUS# X-- NAME --X BASKV AREA V(PU) V(KV) BUS# X-- NAME --X BASKV AREA V(PU) V(KV)

* NONE *

Summary of Olkaria region system bus voltages

Table 2 and **Table 3** below are summaries of key system bus voltages in the Olkaria region at system peak and off peak, respectively prior to and after connection of Olkaria-VAU power plant in year 2027 and, during its operation in years 2032 and 2037.

(a) System Peak

Table 2: Key Olkaria bus Voltages at System peak

Bus	Base case		2027 OLKARIA-V AU CONNECTION		2032 OLKARIA-V AU OPERATION		2037 OLKARIA-V AU OPERATION	
	Voltage (kV)	P. U	Voltage (kV)	P.U.	Voltage (kV)	P.U.	Voltage (kV)	P.U.
Olkaria-II 220 kV	227.5	1.03	226.6	1.03	222.4	1.01	223	1.01
Olkaria-IAU 220 kV	227.5	1.03	226.6	1.03	222.5	1.01	223.1	1.01
Olkaria-III 220 kV	227.4	1.03	226.6	1.03	222.2	1.01	222.7	1.01
Olkaria-IV 220 kV	227.2	1.03	226.3	1.03	223.1	1.01	223.7	1.02
Olkaria-V 220 kV	227.4	1.03	226.5	1.03	223.3	1.02	223.8	1.02
Olkaria-II-EXT 220 kV	227.4	1.03	226.6	1.03	222.4	1.01	223	1.01
Olkaria-VAU 220 kV		0.00	226.5	1.03	222.5	1.01	223.1	1.01
Suswa 220 kV	226.8	1.03	225.9	1.03	221.7	1.01	222.6	1.01
Gilgil 220 kV		0.00		0.00	221.9	1.01	223.3	1.02
Nairobi North 220 kV	221.8	1.01	221.4	1.01	220.8	1.00	217.3	0.99
Suswa 400 kV	412	1.03	410.4	1.03	400.4	1.00	403.9	1.01
Gilgil 400 kV	415	1.04	413.6	1.03	403.1	1.01	406.8	1.02
Olkaria-I 132 kV	136.2	1.03	136	1.03	134	1.02	133.7	1.01
Olkaria-IAU 132 kV	136.2	1.03	135.9	1.03	133.9	1.01	133.6	1.01
Olkaria-II 132 kV	136.4	1.03	136.1	1.03	134	1.02	133.8	1.01
Naivasha 132 kV	135	1.02	135	1.02	133.2	1.01	131.9	1.00

(b) System Off Peak

Table 3: Key Olkaria bus Voltages at system off-peak

Bus	Base case		2027 OLKARIA-VAU CONNECTION		2032 OLKARIA-VAU OPERATION	
	Voltage (kV)	P.U.	Voltage (kV)	P.U.	Voltage (kV)	P.U.
Olkaria-II 220 kV	225.4	1.02	225.2	1.02	222.8	1.01
Olkaria-IAU 220 kV	225.5	1.03	225.2	1.02	222.9	1.01
Olkaria-III 220 kV	225.5	1.03	225.3	1.02	222.5	1.01
Olkaria-IV 220 kV	225.1	1.02	224.8	1.02	223.3	1.02
Olkaria-V 220 kV	225.3	1.02	225	1.02	223.5	1.02
Olkaria-II EXT 220 kV	225.4	1.02	225.2	1.02	222.6	1.01
Olkaria-VAU 220 kV		0.00		0.00	222.9	1.01
Suswa 220 kV	224.3	1.02	223.9	1.02	222.7	1.01
Gilgil 220 kV		0.00		0.00	223.4	1.02
Nairobi North 220 kV	223.7	1.02	222.4	1.01	224.7	1.02
Suswa 400 kV	403.8	1.01	403.5	1.01	403.9	1.01
Gilgil 400 kV	404.1	1.01	404.5	1.01	406.9	1.02
Olkaria-I 132 kV	135.6	1.03	135.5	1.03	134.2	1.02
Olkaria-IAU 132 kV	135.6	1.03	135.4	1.03	134.2	1.02
Olkaria-II 132 kV	135.7	1.03	135.5	1.03	134.2	1.02
Naivasha 132 kV	135.1	1.02	134.7	1.02	134.7	1.02

3.5.2 Load flow diagrams (PQ flows)

The drawings below present load flow diagrams indicating the power flow in Olkaria region for years 2027, 2032 and 2037 grid operation with the proposed power plant. The indicated flows are annotated in MVAs and equipment % loading, while the bus voltages are in kVs and p.u. values. 400kV network is represented in purple, 220 kV network in black and 132 kV in blue colour.

Base case Load Flow Diagrams

(a) System Peak

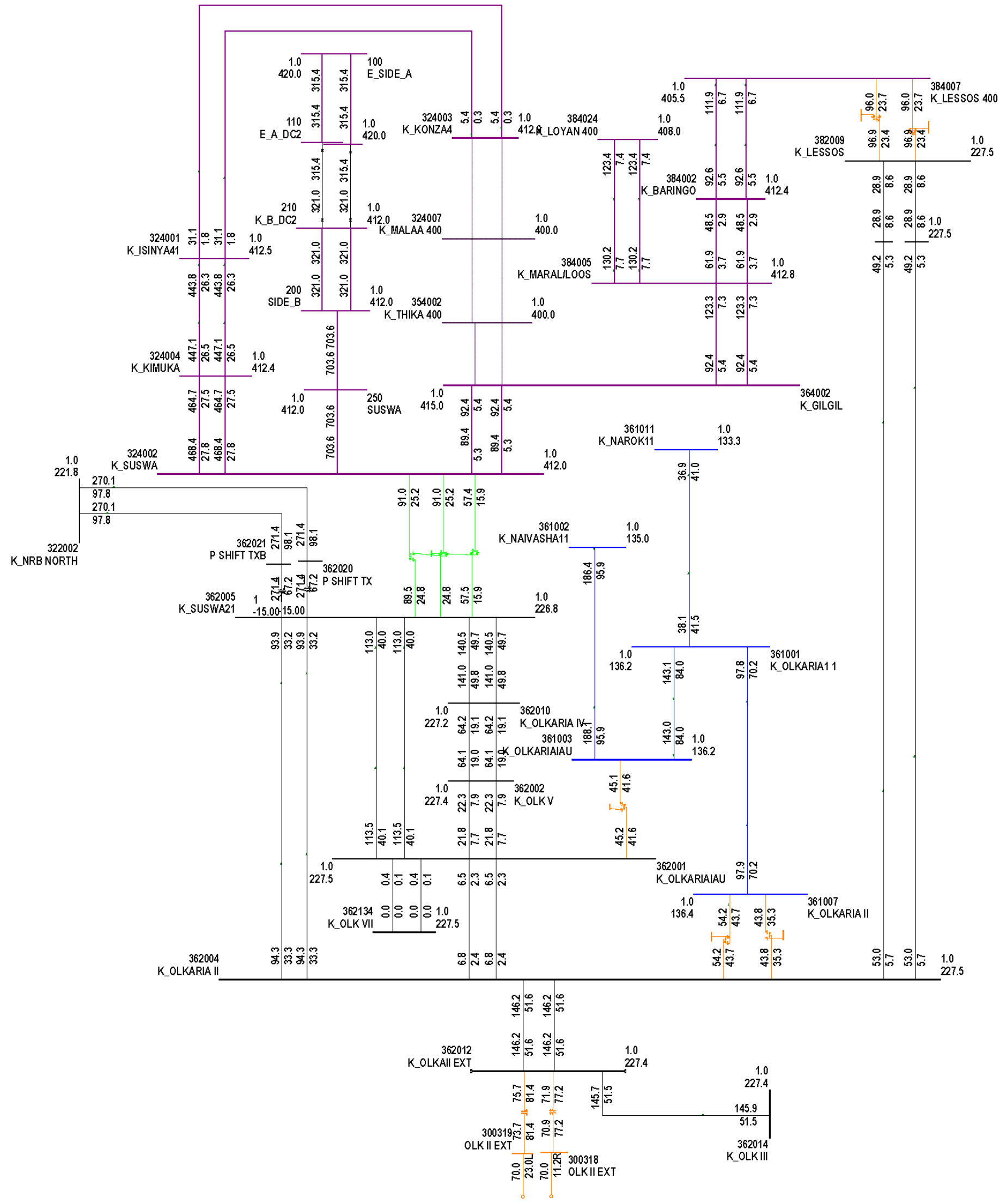
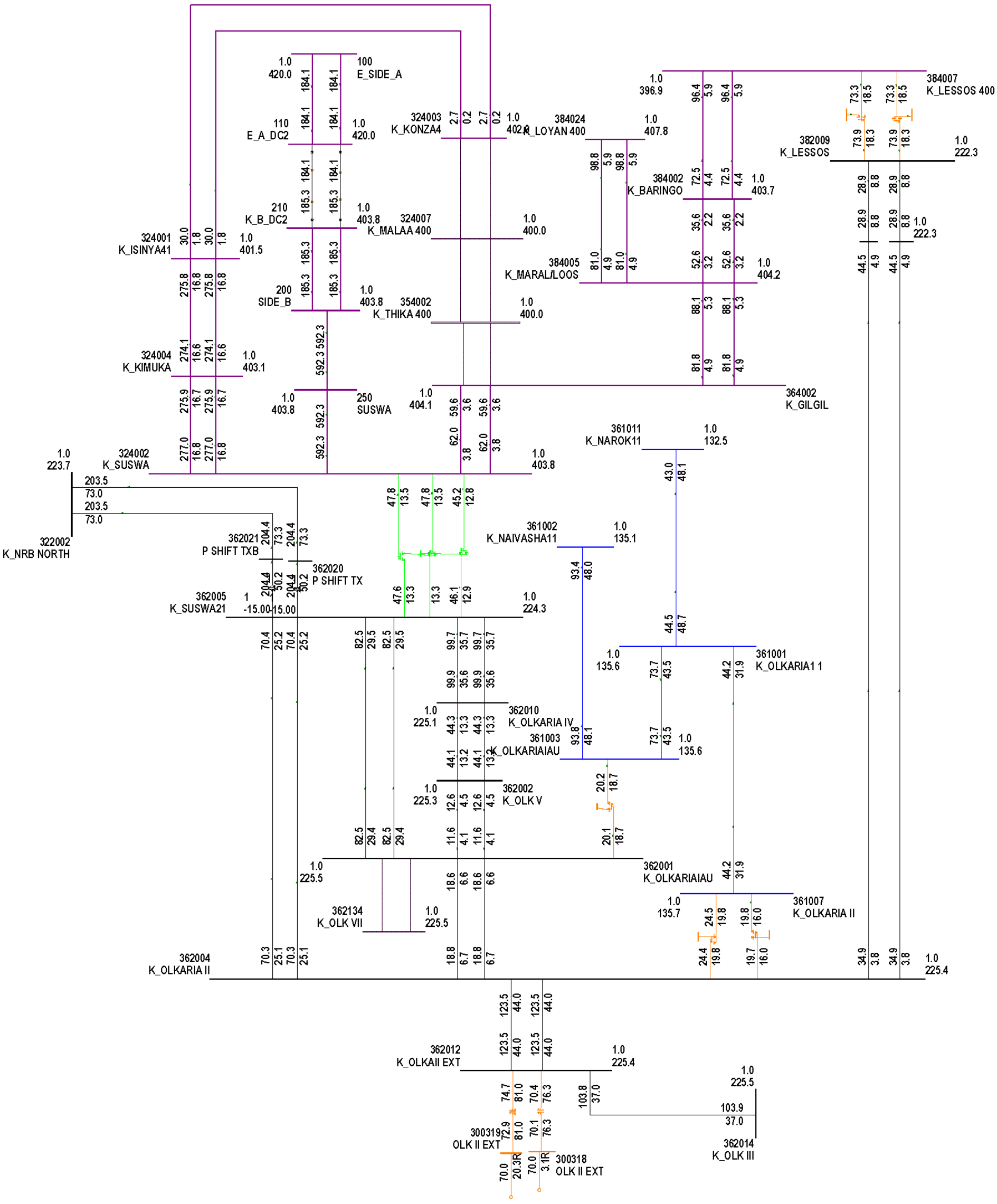


Figure 1. Load Flow: Base case – System Peak

(b) System Off-Peak



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Figure 2. Load Flow: Base case - System Off Peak

2027 Olkaria-VAU Grid connection

(a) System Peak

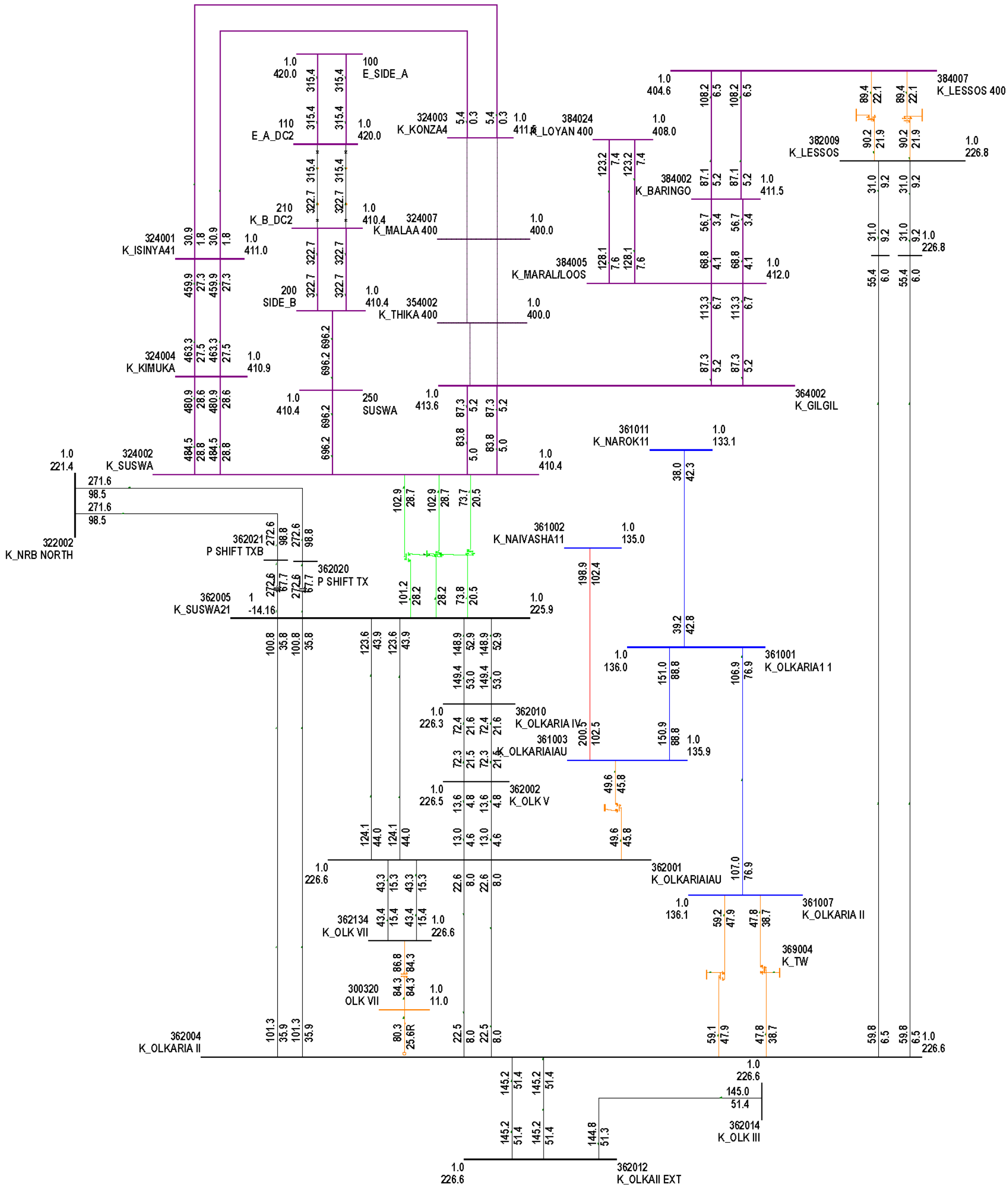
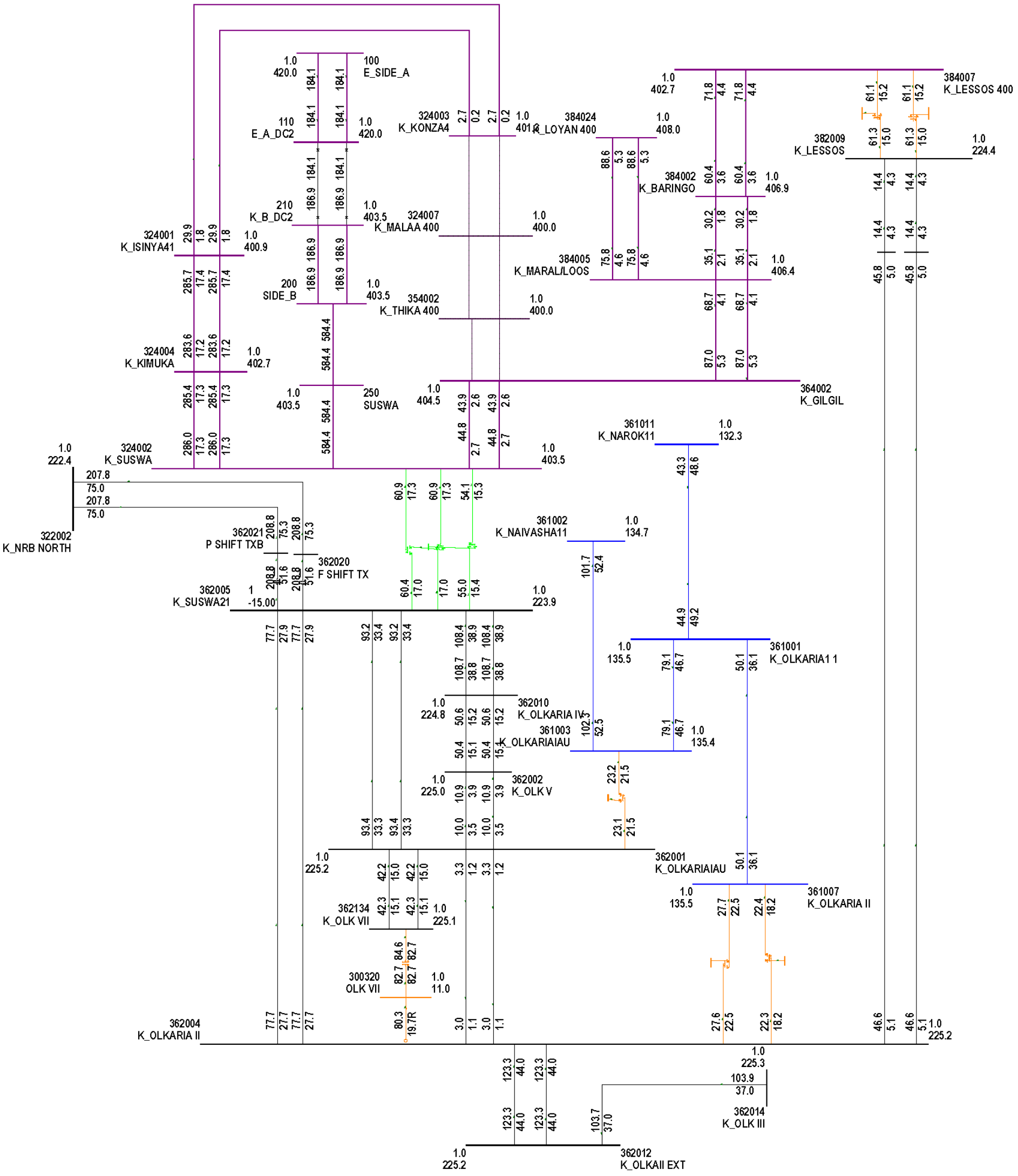


Figure 3. Load Flow: 2027 Olkaria-VAU Grid connection – System Peak

(b) System Off Peak



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Figure 4. Load Flow: 2027 Olkaria-VAU Grid connection – System Off Peak

iv. 2032 Olkaria-VAU Grid operation

(a) System Peak

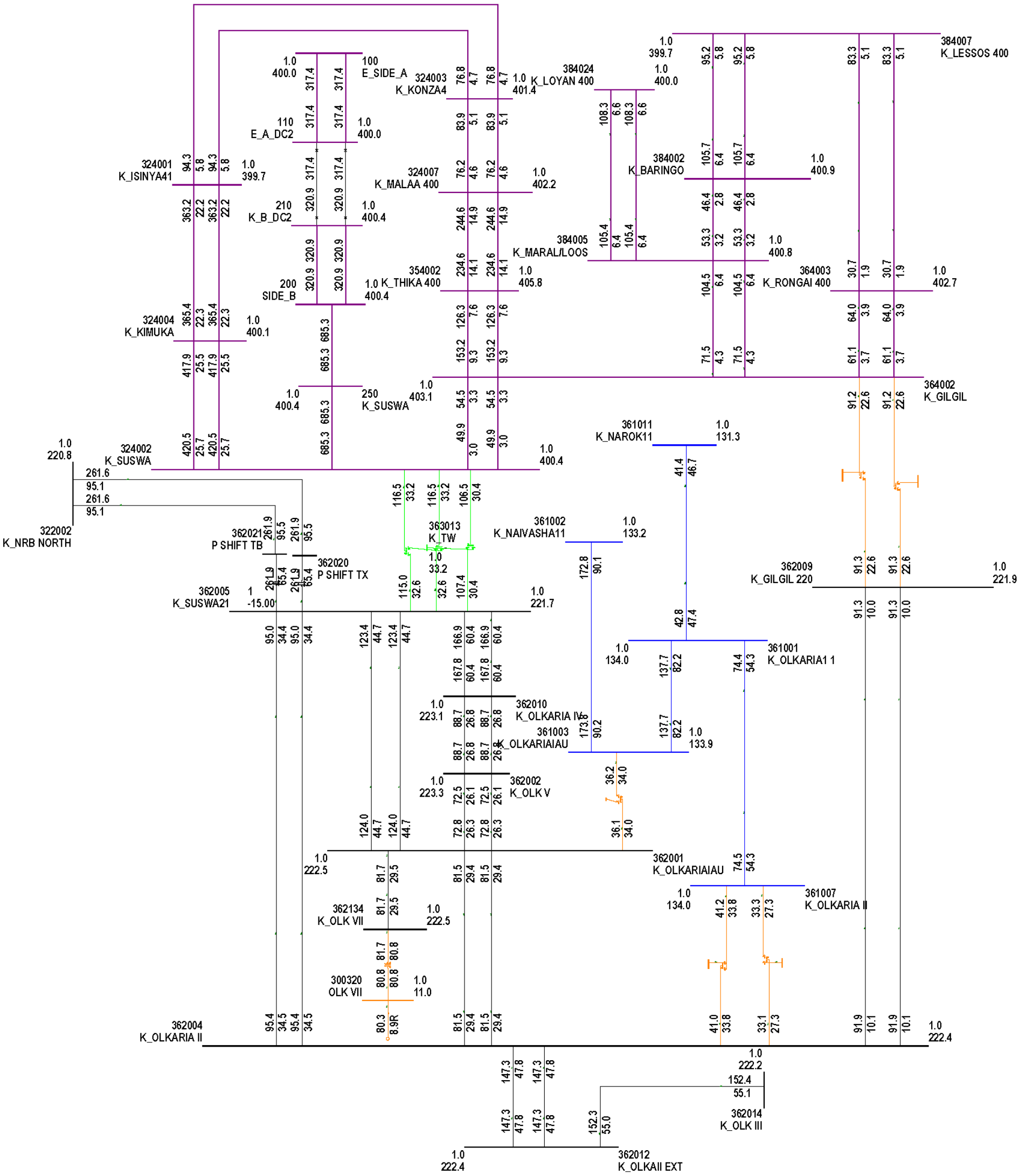
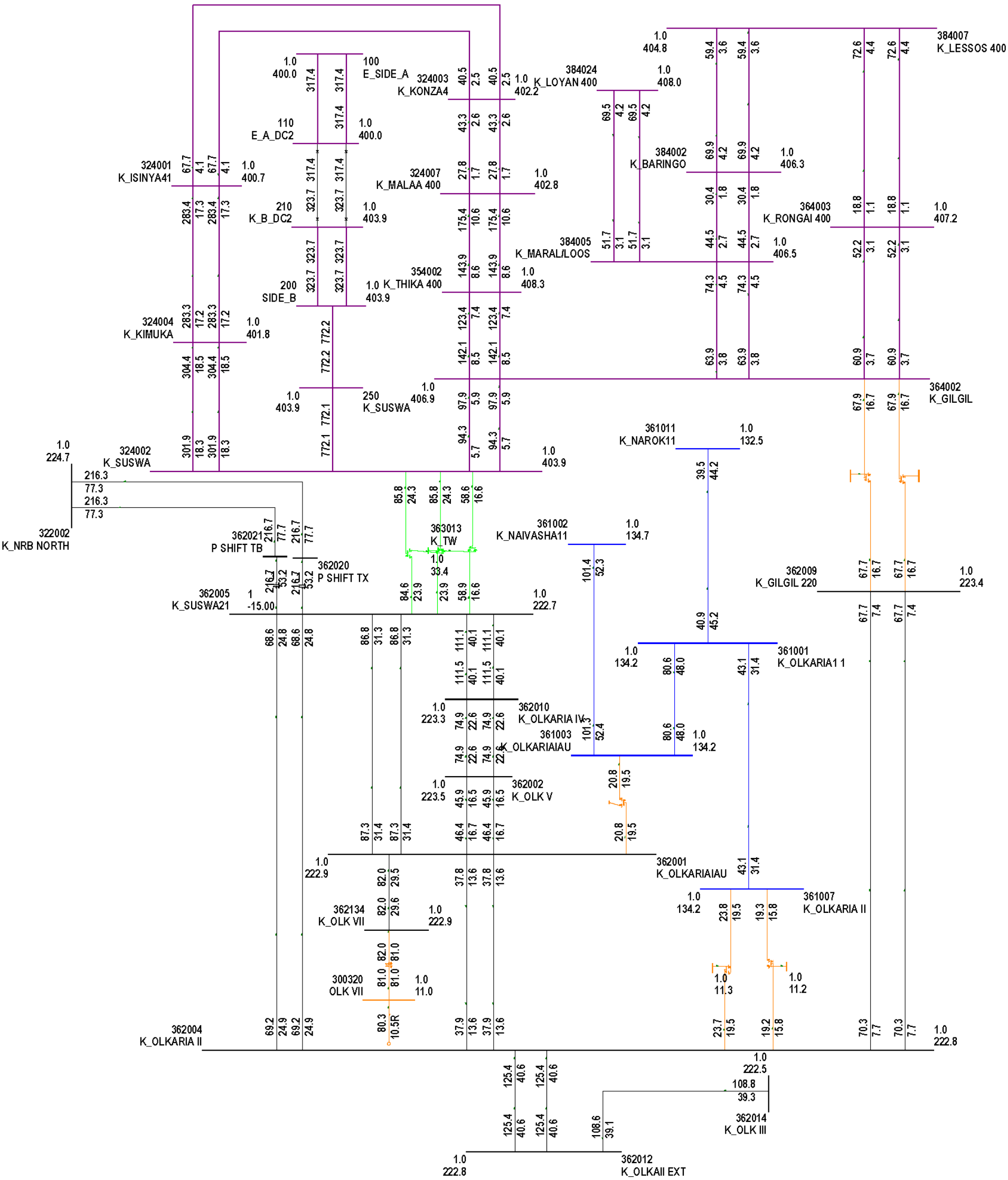


Figure 5. Load Flow: 2032 Olkaria-VAU Grid operation – System Peak

(b) System off Peak



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Figure 6. Load Flow 2032 Olkaria-VAU Grid operation – System Off Peak

v. 2037 Olkaria-VAU Grid operation

(a) System Peak

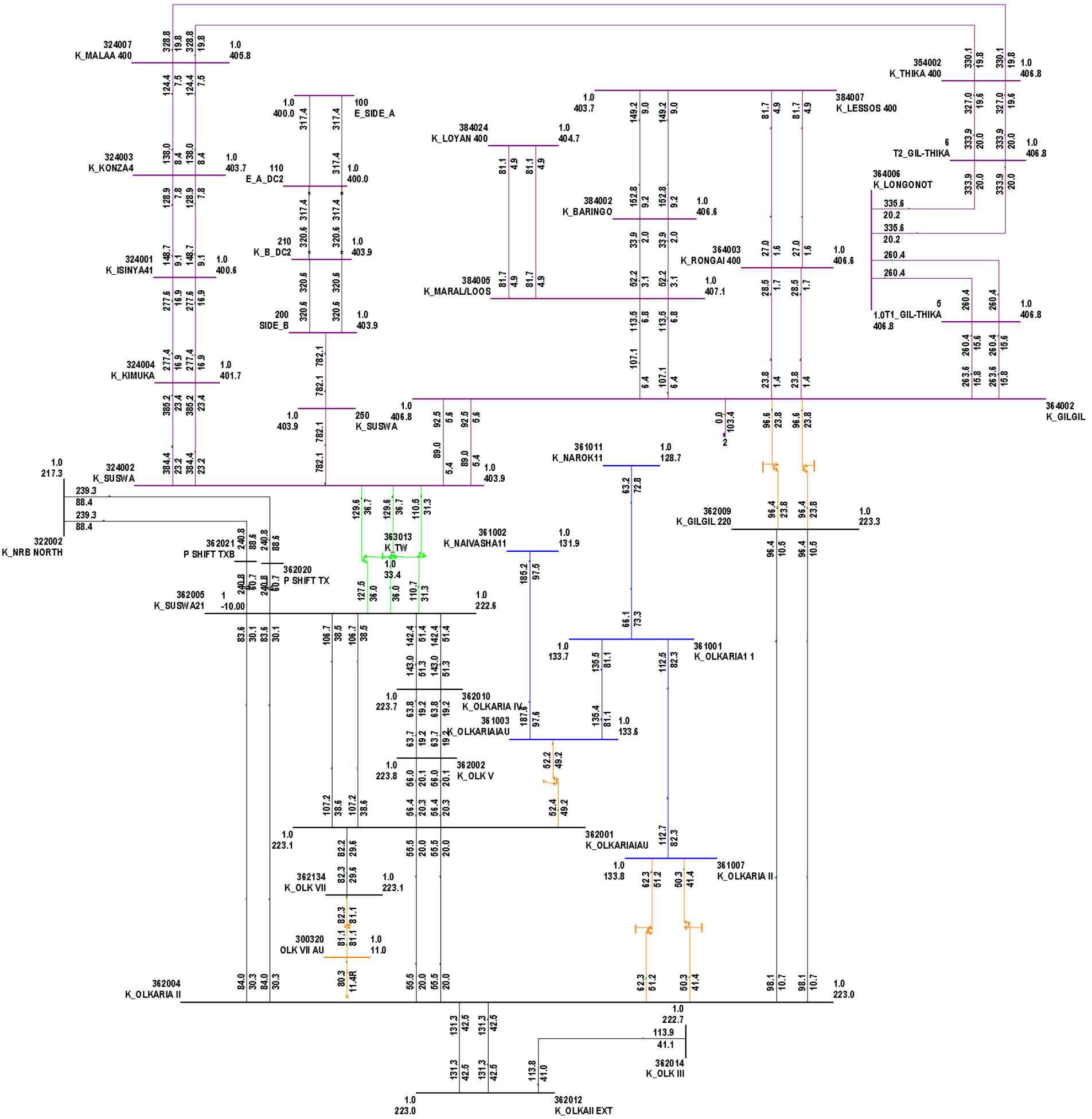


Figure 7. Load Flow: 2037 Olkaria-VAU Grid operation – System Peak

3.5.3 Conclusions

Based on load flow analysis results, it is concluded as follows:

i. Connection of the power plant in 2027 increases network loading resulting to marginal overloading of Olkaria 1U -Naivasha 132 kV line (102.5%) at system peak. Other lines transmitting power from Olkaria to Nairobi including Suswa -Nairobi North 220 kV lines and Naivasha – Ruaraka are also expected to be highly loaded (above 80% at system peak) in all cases. Network loading following connection of the power plant is worst in 2027 as the Gilgil-Thika leg of the planned Nairobi 400 kV transmission ring will not have been commissioned.

ii. The proposed power plant does not result to grid voltage violations when initially connected and during the operation. In all cases bus voltages in Olkaria region are expected to lie between 1.00 p.u. and 1.03 p.u.

4 N-1 (SINGLE) CONTINGENCY ANALYSIS

4.1 Introduction

Contingency analysis is carried out to determine grid reliability and therefore security following a disturbance that results in the loss of one or more power system equipment. For a power system to be said to be reliable and secure, it must have continuity of supply without loss of load or resulting to a cascade of outages following the disturbance.

The objective of contingency analysis is to identify any loading or voltage range violations in the grid considering the criteria defined in the national grid code under contingency conditions. The voltage criteria defined in the grid code states at steady state following a single contingency (N-1) for 132 and 220kV nodes, voltages should be within ±10% of nominal values. For 400kV nodes, voltage should be within ± 5% of nominal values. Loading criteria provides that during contingency conditions equipment loading may be allowed to increase to 120%, which is a threshold justified by the fact that the equipment can withstand this overload level for a short duration of time, the time that the operator may take to apply remedial actions to address the situation.

4.2 Methodology

Following conclusion of load flow studies, to determine compliance with the grid code on integration of the new power plant, single contingency analysis was carried out. The analysis considered transmission equipment from 132 kV voltage level and above in Olkaria region, defined as the 132, 220 and 400 kV grid in the neighbourhood of the proposed Olkaria V AU power plant connection nodes.

4.3 CONTINGENCY ANALYSIS RESULTS

The sections below present results of expected single contingency equipment overloads, voltage violations and worst contingencies ranking for the base case and the considered power plant grid connection options under both system peak and off-peak conditions.

Base case 2027

a) System Peak

i. Equipment overloads

None

ii. Voltage range and deviation violations

BUS	CONTINGENCY	BASE VOLTS	CONT VOLTS	DEVIATION	RANGE VIO	DEV VIO
NAROK 132	OPEN OLKARIA1-NAROK 132 kV LINE	1.00873	0.96096	-0.04777		-0.01777

iii. Single Contingency Equipment loading above 85%

MONITORED EQUIPMENT	CKT	CONTINGENCY	RATING	FLOW	
			MVA	MVA	%
SUSWA -NAIROBI NORTH 220	1	BASE CASE	274	271	98.1
SUSWA -NAIROBI NORTH 220	2	BASE CASE	274	271	98.1
OLKARIA-IAU -NAIVASHA 132	1	BASE CASE	190	188.3	96.2
OLKARIA-IAU -NAIVASHA 132	1	OPEN OLKARIA -NAROK 132	209	200	92.9
OLKARIA-II - OLKARIA II EXT	2	OPEN OLKARIA-II – OLKARIA-II EXT 220	305	291.9	92.7
OLKARIA-II - OLKARIA II EXT	1	OPEN OLKARIA-II -OLKARIA-II EXT 220	305	291.9	92.7
OLKARIA-IAU -NAIVASHA 132	1	OPEN OLKARIA-II-LESSOS 220	209	191.7	89.2
OLKARIA-IAU -NAIVASHA 132	1	OPEN OLKARIA-II-LESSOS 220	209	191.7	89.2
SUSWA - NAIROBI NORTH 220	1	OPEN OLKARIA-IAU - NAIVASHA 132	305	272.6	88.8
SUSWA - NAIROBI NORTH 220	2	OPEN OLKARIA-IAU - NAIVASHA 132	305	272.6	88.8
OLKARIA-IAU -NAIVASHA 132	1	OPEN OLKARIA-IAU - SUSWA 220	209	190.7	88.6
OLKARIA-IAU -NAIVASHA 132	1	OPEN OLKARIA-IAU - SUSWA 220	209	190.7	88.6
SUSWA - NAIROBI NORTH 220	1	OPEN OLKARIA-II-LESSOS 220	305	271.1	88.5
SUSWA - NAIROBI NORTH 220	2	OPEN OLKARIA-II-LESSOS 220	305	271.1	88.5
SUSWA - NAIROBI NORTH 220	1	OPEN GILGIL-LOOSUK 400	305	271	88.5
SUSWA - NAIROBI NORTH 220	2	OPEN GILGIL-LOOSUK 400	305	271	88.5

b) System off peak

vi. Equipment overloads

None

vii. Voltage range and deviation violations

None

viii. Single contingency loading above 75%

MONITORED EQUIPMENT	CCT	CONTINGENCY	RATING	FLOW	
			MVA	MVA	%
SUSWA-NAIROBI NORTH 220	2	OPEN SUSWA -NAIROBI NORTH 1	305	269	87
SUSWA-NAIROBI NORTH 220	1	OPEN SUSWA -NAIROBI NORTH 2	305	269	87

2027 Olkaria V AU Grid Connection

a) System Peak

i. Equipment overloads

MONITORED EQUIPMENT	CKT	CONTINGENCY	RATING	FLOW	
			MVA	MVA	%
OLKARIA-IAU -NAIVASHA 132	1	BASE CASE	190	201.5	102.8

ii. Voltage range and deviation violations

(NONE)

iii. Single Contingency Equipment loading above 80%

MONITORED EQUIPMENT	CKT	CONTINGENCY	CKT	RATING	FLOW	
				MVA	MVA	%
SUSWA -NAIROBI 220	1	BASE CASE		274	270.9	97.4
SUSWA -NAIROBI 220	2	BASE CASE		274	270.9	97.4
OLKARIA-IAU -NAIVASHA	1	BASE CASE		190	201.5	102.8
OLKARIA-IAU -NAIVASHA	1	OPEN ISINYA - KIMUKA 400	1	209	214	99.8
OLKARIA-IAU -NAIVASHA	1	OPEN ISINYA - KIMUKA 400	2	209	214	99.8
OLKARIA-IAU -NAIVASHA	1	OPEN OLKARIA-I -NAROK 132	1	209	213.6	99.2
OLKARIA-IAU -NAIVASHA	1	OPEN OLKARIA-II -LESSOS 220	1	209	205.4	95.5
OLKARIA-IAU -NAIVASHA	1	OPEN OLKARIA-II -LESSOS 220	2	209	205.4	95.5
OLKARIA-IAU -NAIVASHA	1	OPEN OLKARIA-1AU -SUSWA 220	1	209	204.2	94.7
OLKARIA-IAU -NAIVASHA	1	OPEN OLKARIA-1AU -SUSWA 220	2	209	204.2	94.7
OLKARIA-IAU -NAIVASHA	1	OPEN OLKARIA-II-SUSWA 220	1	209	203.8	94.6
OLKARIA-IAU -NAIVASHA	1	OPEN OLKARIA-II-SUSWA 220	2	209	203.8	94.6
OLKARIA-IAU -NAIVASHA	1	OPEN OLKARIA-IV -SUSWA 220	1	209	203.8	94.6
OLKARIA-IAU -NAIVASHA	1	OPEN OLKARIA-IV -SUSWA 220	2	209	203.8	94.6
OLKARIA-IAU -NAIVASHA	1	OPEN GILGIL - LOOSUK 400	1	209	202.5	94.4
OLKARIA-IAU -NAIVASHA	1	OPEN GILGIL - LOOSUK 400	2	209	202.5	94.4

ix.

b) System off-Peak

i. Equipment overloads

NONE

ii. Voltage range and deviation violations

NONE

iii. Single contingency loading above 80%

MONITORED EQUIPMENT	CKT	CONTINGENCY	CKT	RATING	FLOW	
				MVA	MVA	%
SUSWA-NAIROBI NORTH 220	2	OPEN SUSWA – NAIROBI NORTH 220	1	305	273.6	89.2
SUSWA-NAIROBI NORTH 220	1	OPEN SUSWA – NAIROBI NORTH 220	2	305	273.6	89.2
OLKARIA-II EXT - OLKARIA II 220	2	OPEN OLKARIA-II EXT – OLKARIA-II 220	1	305	246.6	79
OLKARIA-II EXT - OLKARIA II 220	1	OPEN OLKARIA-II EXT – OLKARIA-II 220	2	305	246.6	79

2032 Olkaria V AU Grid Operation

a) System Peak

i. Equipment overloads

NONE

ii. Voltage range and deviation violations

NONE

iii. Single Contingency Equipment loading above 80%

MONITORED EQUIPMENT	CKT	CONTINGENCY	CKT	RATING	FLOW	
				MVA	MVA	%
SUSWA -NAIROBI NORTH 220	2	BASE CASE		274	261.9	95.5
SUSWA -NAIROBI NORTH 220	1	BASE CASE		274	261.9	95.5
OLKARUA-IAU - OLKARA 1 132	1	BASE CASE		165	137.7	82.2
OLKARIA-IAU -NAIVASHA 132	1	BASE CASE		190	173.8	90.2
OLKARIA-II EST -OLKARIA II 220	2	OLKARIA II EXT -OLKARIA II 220	1	305	294.6	95.6
OLKARIA-II EST -OLKARIA II 220	1	OLKARIA II EXT -OLKARIA II 220	2	305	294.6	95.6
OLKARIA-IAU -NAIVASHA 132	1	OPEN SUSWA -NAIROBI NORTH 220	2	209	197.8	93.3
OLKARIA-IAU -NAIVASHA 132	1	OPEN SUSWA -NAIROBI NORTH 220	1	209	197.8	93.3
OLKARIA-IAU -NAIVASHA 132	1	OPEN SUSWA -NAIROBI NORTH 220	1	209	197.8	93.2
OLKARIA-IAU -NAIVASHA 132	1	OPEN SUSWA -NAIROBI NORTH 220	1	209	197.8	93.2

x.

a) System off-Peak

i. Equipment overloads

NONE

ii. Voltage range and deviation violations

NONE

iii. Single contingency equipment loading above 80%

MONITORED EQUIPMENT	CKT	CONTINGENCY	CKT	RATING	FLOW	%
SUSWA -NAIROBI NORTH 220kV	1	OPEN SUSWA -NAIROBI NORTH 220kV	1	274	263.6	94.3
SUSWA -NAIROBI NORTH 220kV	2	OPEN SUSWA -NAIROBI NORTH 220kV	1	274	263.6	94.3
OLKARIA-II EXT -OLK II 220kV	2	OPEN OLKARIA-II EXT -OLKARIA-II 220kV	1	305	250.8	81.2
OLKARIA-II EXT -OLK II 220kV	1	OPEN OLKARIA-II EXT -OLKARIA-II 220kV	2	305	250.8	81.2
SUSWA -NAIROBI NORTH 220kV	2	OPEN OLKARIA-IAU-NAIVASHA132 kV	1	274	223.1	80.1
SUSWA -NAIROBI NORTH 220kV	2	OPEN SUSWA -KIMUKA 400kV	1	274	221	79.5
SUSWA -NAIROBI NORTH 220kV	1	OPEN SUSWA -KIMUKA 400kV	2	274	221	79.5

2037 Olkaria V AU Grid Operation

a) System Peak

i. equipment overloads

NONE

ii. Voltage range and voltage deviation violations

NONE

iii. Single Contingency Equipment loading above 80%

MONITORED EQUIPMENT	CONTINGENCY	RATING	FLOW	
		MVA	MVA	%
OLKARIA 1AU-NAIVASHA 132	BASE CASE	190	187.6	97.5
OLKARIA 1AU-NAIVASHA 132	OPEN OLKARIA 1-NAROK 132	209	210.5	99.6
OLKARIA 1AU-NAIVASHA 132	OPEN SUSWA -NAIROBI NORTH 220	209	205.8	97.3
OLKARIA 1AU-NAIVASHA 132	OPEN SUSWA -NAIROBI NORTH 220	209	205.7	97.3
OLKARIA 1-NAROK 132	OPEN OLKARIA1AU-NAIVASHA 132	89	85.2	94.3
OLKARIA 1-OLKARIA 1AU 132	OPEN OLKARIA 1-NAROK 132	181	171	93.3
OLKARIA 1AU-NAIVASHA 132	OPEN OLKARIA II - GILGIL 220 - 1	209	192.4	91
OLKARIA 1AU-NAIVASHA 132	OPEN OLKARIA II - GILGIL 220 -2	209	192.4	91
OLKARIA 1AU-NAIVASHA 132	OPEN SUSWA -KIMUKA 400 -1	209	191.6	90.6
OLKARIA 1AU-NAIVASHA 132	OPEN SUSWA -KIMUKA 400 - 2	209	191.6	90.6
SUSWA NAIROBI NORTH 220	OPEN SUSWA -NAIROBI NORTH 220 -2	305	271.9	90.5
SUSWA NAIROBI NORTH 220	OPEN SUSWA -NAIROBI NORTH 220 -1	305	272	90.4
OLKARIA 1AU-NAIVASHA 132	OPEN KIMUKA -ISINYA 400 - 1	209	190.5	90.1
OLKARIA 1AU-NAIVASHA 132	OPEN KIMUKA -ISINYA 400 - 2	209	190.5	90.1

b) System off-Peak

i. equipment overloads

None

ii. Voltage range and voltage deviation violations

None

iii. Single Contingencies resulting to high lines loading

MONITORED EQUIPMENT	CKT	CONTINGENCY	CKT	RATING	FLOW	
				MVA	MVA	%
OLKARIA II -OLKARIA II EXT 220KV	2	OPEN OLKARIA II EXT -OLKARI II 220KV	1	305	262.8	85
OLKARIA II -OLKARIA II EXT 220KV	1	OPEN OLKARIA II EXT -OLKARI II 220KV	2	305	262.8	85
SUSWA-NAIROBI NORTH 220KV	2	OPEN SUSWA -NAIROBI NNORTH 220KV	1	305	232	75.2
SUSWA-NAIROBI NORTH 220KV	1	OPEN SUSWA -NAIROBI NNORTH 220KV	2	305	232	75.2

4.4 Conclusions

Based on contingency analysis results, the following conclusions are made:

(i) Connection of the power plant in 2027 and operation in 2032 and 2037 will not result to single contingency overloads under both peak and off-peak load conditions in Olkaria region considering short term contingency rating as 110% of continuous rating.

(ii) However, in 2027 Olkaria-IAU -Naivasha 132 kV line is expected to be slightly overloaded (102.5%) at zero contingency.

5 FAULT LEVEL ANALYSIS

5.1 INTRODUCTION

Integration of the new power plant is expected to contribute to short current during fault conditions and therefore increase fault levels especially at neighbouring grid nodes. The resultant fault levels on integration of the new power plant should not exceed 80% of the existing grid breakers interruption capacity.

Short circuit fault levels also indicate the relative strength of the grid at various buses with respect to the connection of the proposed power plant. For a particular power plant, the indicative measure of grid strength is determined by the short circuit ratio, determined as follows:

- Short Circuit Ratio (SCR) with respect to connection of the power is,
- Fault level at the bus (MVA) / Power plant rating (MW)
- A particular bus is considered strong with respect to the connection of a power plant if SCR is greater than 20 and weak if SCR is less than 10.

5.2 Methodology

Three phase short circuit fault level calculations were carried out prior and after integration of the power plant to determine its impact. The results were compared to establish cases of significant changes in fault levels on connection of the new power plant. The calculated fault levels were also compared with the rated grid circuit breaker capacities and any upgrade requirements identified.

Based on the calculated fault levels short circuit ratios at the identified potential power plant connection buses were also determined.

5.3 Short Circuit Fault Level Calculation Results

The tables below summarize three phase short circuit fault levels for the Base case and the considered connection options under system peak and off-peak conditions.

a) System Peak

Bus	**3-phase Short Circuit Fault Levels**							
	Base case		**2027 Connection**		**2032 0peration**		**2037 operation**	
	MVA	**Amps**	**MVA**	**Amps**	**MVA**	**Amps**	**MVA**	**Amps**
Olkaria-II 220 kV	6964.6	18277.4	6968.7	18288.2	7759.0	20362.2	9368.4	24585.7
Olkaria-IAU 220 kV	7029.4	18447.3	7025.4	18436.9	7838.9	20571.8	9452.4	24806.0
Olkaria-III 220 kV	5239.8	13751.0	5245.2	13765.0	5694.0	14942.8	6330.0	16612.0
Olkaria-IV 220 kV	6355.1	16677.8	6362.4	16697.1	7028.4	18444.7	8304.7	21794.1
Olkaria-V 220 kV	6500.3	17058.9	6505.2	17071.7	7196.6	18886.3	8513.6	22342.4
Olkaria-VI 220 kV	7119.4	18683.7	6889.8	18081.0	7758.8	20361.6	9368.1	24584.8
Olkaria-VAU 220 kV			6493.2	17040.2	7835.9	20563.8	9447.9	24794.4
Suswa 220 kV	6546.1	17179.1	6570.6	17243.4	7619.2	19995.3	9589.3	25165.5
Gilgil 220 kV					5482.7	14388.3	6755.8	17729.5
Nairobi North 220 kV	2744.6	7202.7	2782.9	7303.2	3649.1	9576.4	4075.8	10696.2
Suswa 400 kV	5581.9	8056.8	5626.5	8121.1	8060.1	11633.8	10866.6	15684.6

Kimuka 400 kV	5058.1	7300.7	5100.3	7361.7	7447.6	10749.7	9498.6	13710.1
Gilgil 400 kV	4931.2	7117.6	4971.6	7175.9	8305.9	11988.5	13589.7	19615.0
Olkaria-I 132 kV	3270.2	14303.2	3277.4	14335.1	3391.9	14835.7	3572.8	15627.0
Olkaria-IAU 132 kV	3208.9	14035.2	3216.4	14067.9	3323.1	14534.7	3500.5	15310.7
Olkaria-II 132 kV	3098.7	13553.4	3105.1	13581.3	3194.6	13972.6	3361.8	14704.2
Olkaria-V-AU 132 kV								
Naivasha 132 kV	2490.5	10893.2	2500.9	10938.6	2622.8	11471.9	2792.9	12215.6

5.4 BREAKER RATINGS AT KEY SUBSTATIONS IN OLKARIA REGION

Substation	Voltage(kV)	Breaker Short Circuit Rating (kA)
Olkaria-II	220kV	40
Olkaria-IAU	220kV	31.5
Suswa	220kV	31.5
Olkaria IV	220kV	31.5
Olkaria 1AU	132kV	31.5
Olkaria I	132kV	31.5
Naivasha	132kV	25
SUSWA	400kV	50

5.5 SHORT CIRCUIT RATIOS 2027

	System Peak	
BUS	**MVA**	**SCR**
Olkaria-II 220 kV	6968.7	86.8
Olkaria-IAU 220 kV	7025.4	87.5
Olkaria-VAU 220 kV	6493.2	80.9
Olkaria-I 132 kV	3277.4	40.8

5.6 CONCLUSIONS

Based on short circuit fault level analysis it is concluded as follows:

(i) The connection of the power plant increases short circuit fault levels at the neighbouring buses. However, the resultant fault levels are expected to be much lower than the short circuit capacities of the existing grid circuit breakers, which are at least 25 kA.

(ii) system fault levels are expected to increase substantially by the year 2032 and year 2037; however, the existing breaker current limits will not be exceeded.

(iii) The identified power plant connection point (Olkaria-IAU 220 kV) is strong with respect to the connection of the 80.3 MW power plant.

(iv) It follows that the new power plant will not result in significant voltage variation or voltage instability in case of tripping under full load operation.

6 TRANSIENT STABILITY ANALYSIS

6.1 INTRODUCTION

A power system is considered unstable if at least one generator unit goes out of synchronism following a large disturbance (such as three-phase line short circuit).

Transient stability depends on both the initial operating state of the system and the severity of the disturbance. Instability is usually manifested in the form of a periodic angular separation due to insufficient synchronizing torque (first swing instability). The time frame of interest in transient stability studies is usually 3-10 seconds following the disturbance.

6.2 METHODOLOGY

The Kenya Grid Code requires that each generating unit, shall be capable of continuous uninterrupted operation during the occurrence of a range of voltage variation conditions, including the voltage dip caused by a transmission system fault which causes voltage at the point of connection to drop to zero for up to 0.175 seconds in any one phase or combination of phases, followed by a period of ten (10) seconds where voltage may vary in the range 80-110% of the nominal voltage.

Transient analysis was therefore carried out to demonstrate compliance with the grid code requirements on integration of the new power plant in 2027. This entailed simulation of various system disturbances on the established grid connection scheme, plotting and analysing the power system transient responses.

For each of the simulated disturbances generator rotor angles, Voltage and frequency responses at key power system buses in Olkaria region were monitored and plotted. Power generation at the new power plant and loading of key lines during and after the disturbances were also monitored and plotted where applicable.

The following disturbances were simulated and analysed:

- Fault and trip of Olkaria-IAU – Naivasha 132 kV line
- Fault and trip of Olkaria-IAU – Suswa 220 kV line cct 1
- Fault and trip of Suswa -Nairobi North line 220 kV line cct 1
- Sustained fault on Olkaria-V – Olkaria-IAU 220 kV line
- Loss of Olkaria-VAU generator
- Loss of Olkaria-IAU unit 6
- Loss of Olkaria-IAU plant
- Fault and trip of Olkaria-III – Olkaria-II extension 220 kV line with loss of Olkaria plant generation.

In this study the simulated short circuit faults are assumed to be normally cleared within 100ms and within 175ms in case of sustained faults.

6.3 TRANSIENT STABILITY ANALYSIS RESULTS

6.3.1 Three-phase Fault and trip of Olkaria-IAU – Naivasha 132 kV line

6.3.1.1 Rotor angle response

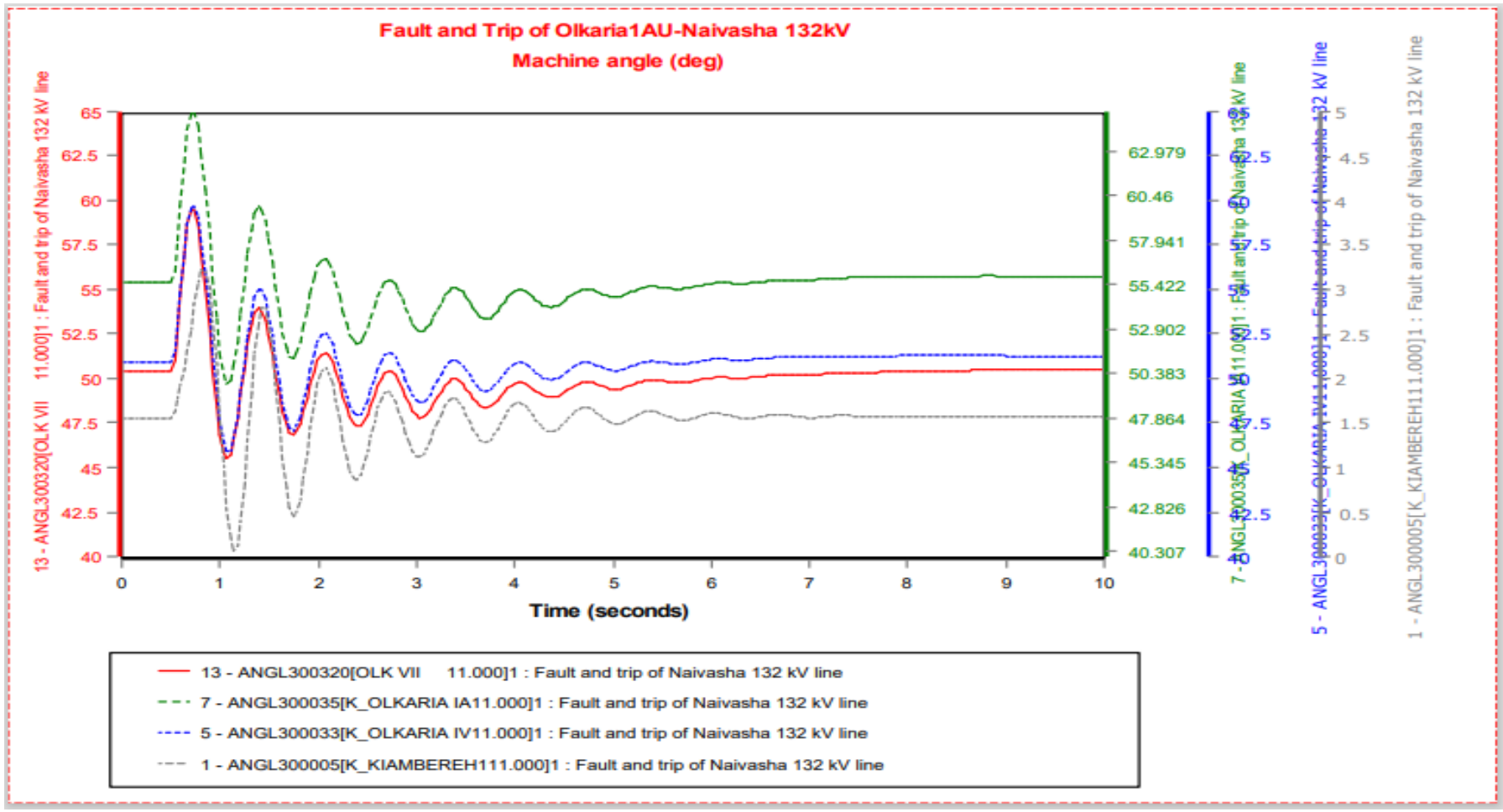


Figure 8 Three-phase fault and trip of Olkaria-IAU – Naivasha 132 kV line - Rotor angle response

6.3.1.2 Frequency response

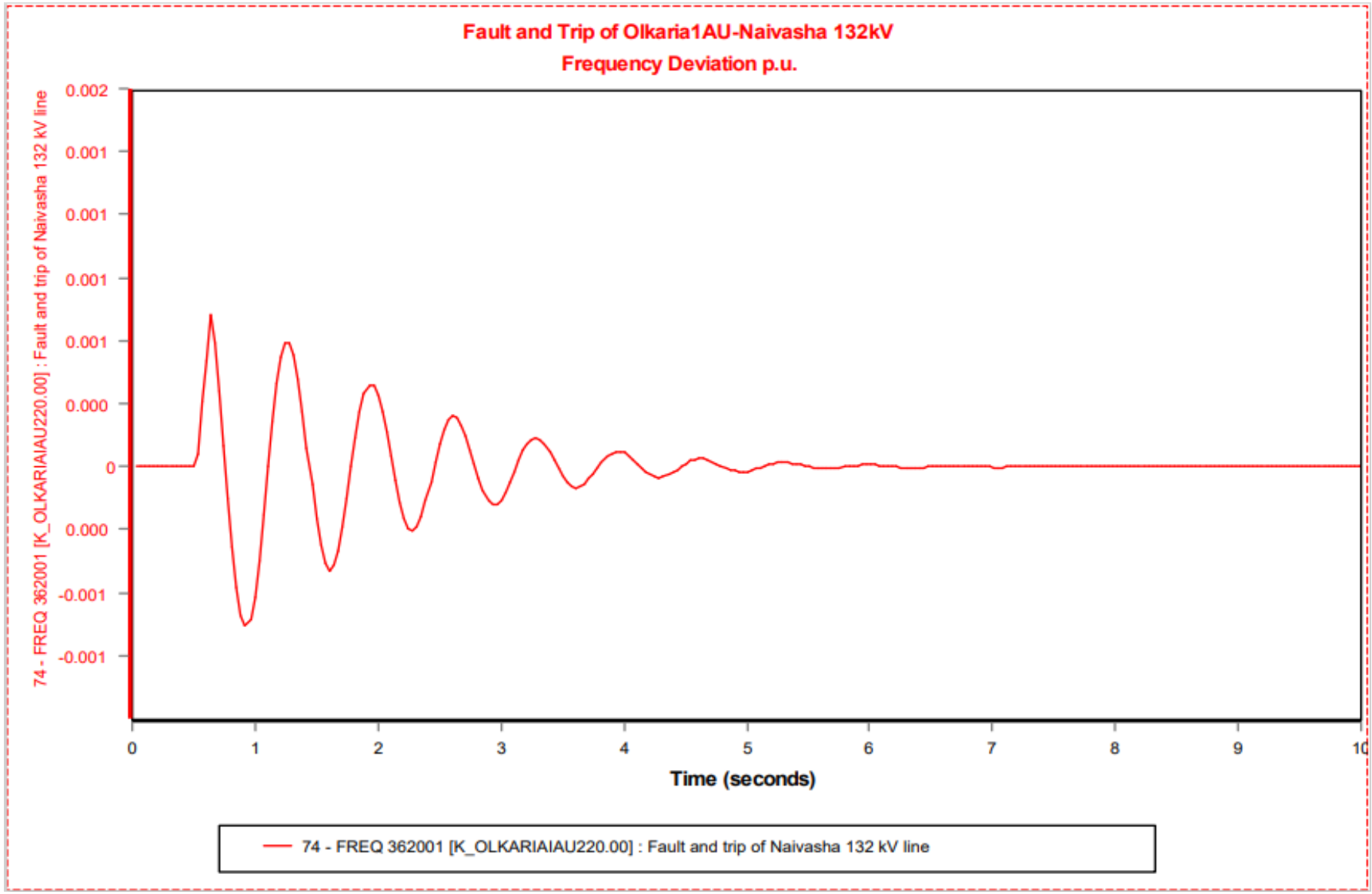


Figure 9. Three-phase fault and trip of Olkaria-IAU – Naivasha 132 kV line – Frequency response

6.3.1.3 Voltage response

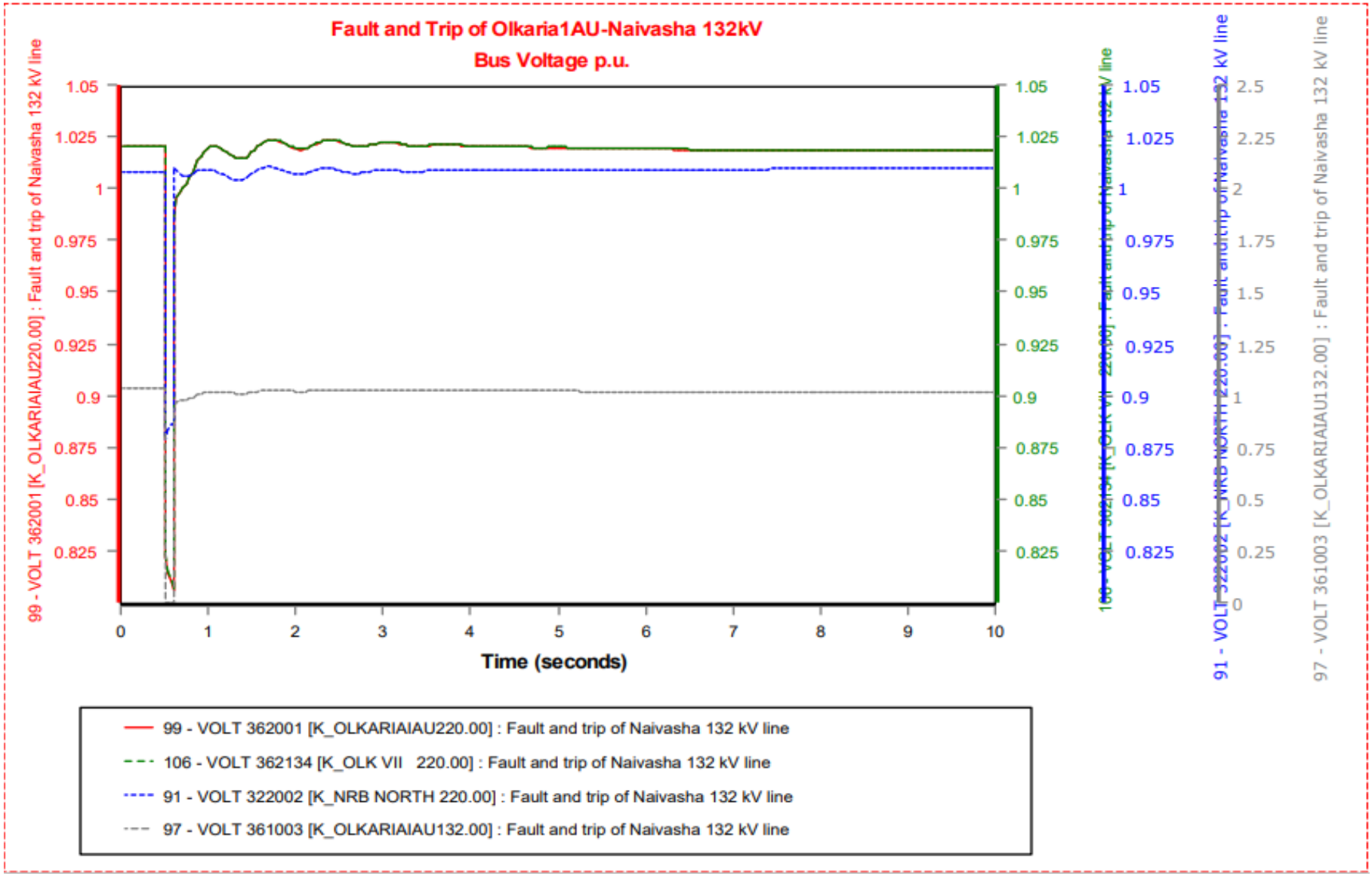


Figure 10. Three-phase fault and trip of Olkaria-IAU – Naivasha 132 kV line – Voltage response

6.3.2 Three-phase fault on Olkaria-IAU – Suswa 220 kV line

6.3.2.1 Rotor angle response

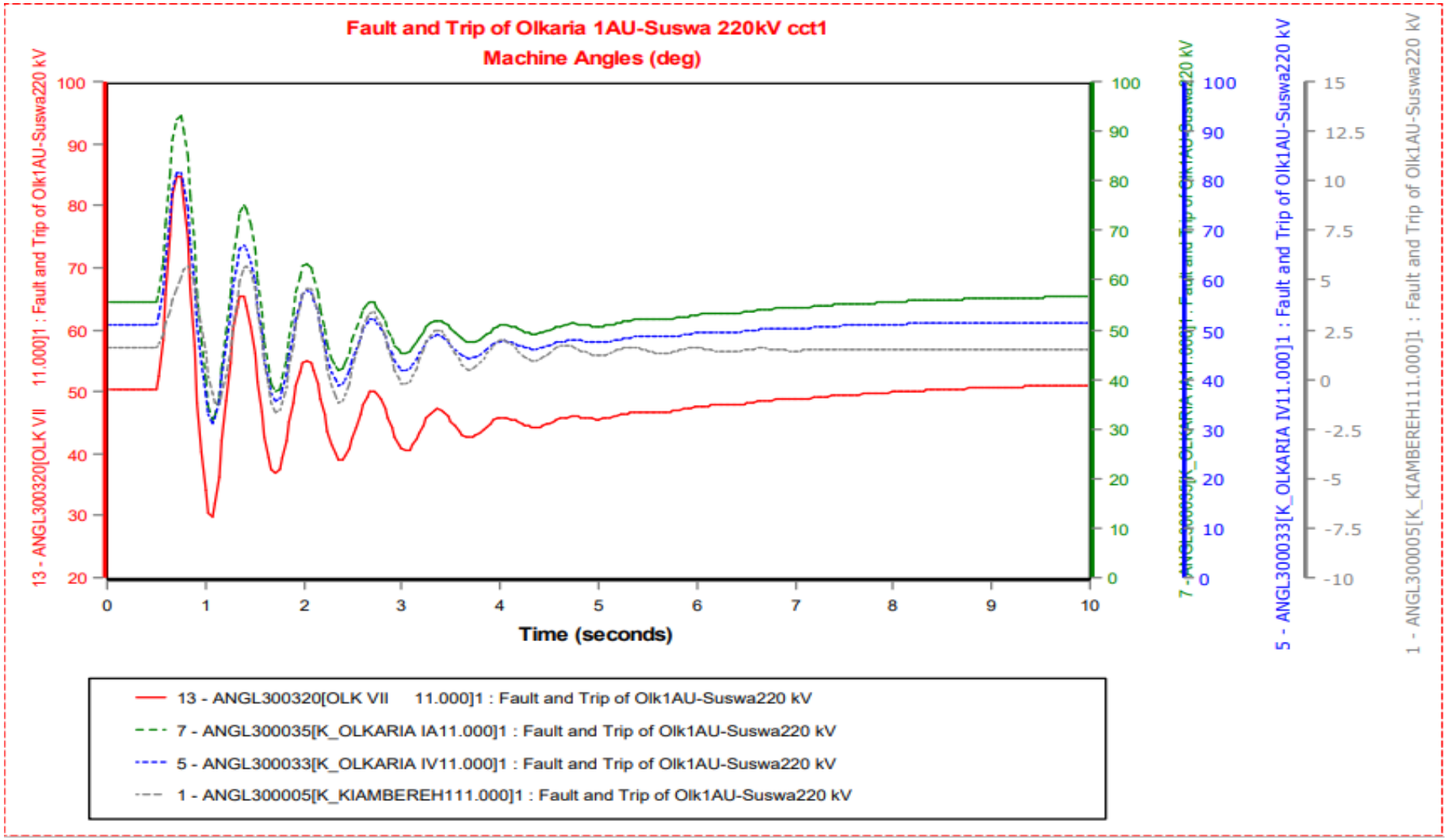


Figure 11. Three-phase fault on Olkaria-IAU – Suswa 220 kV line – Rotor angle response

6.3.2.2 Frequency response

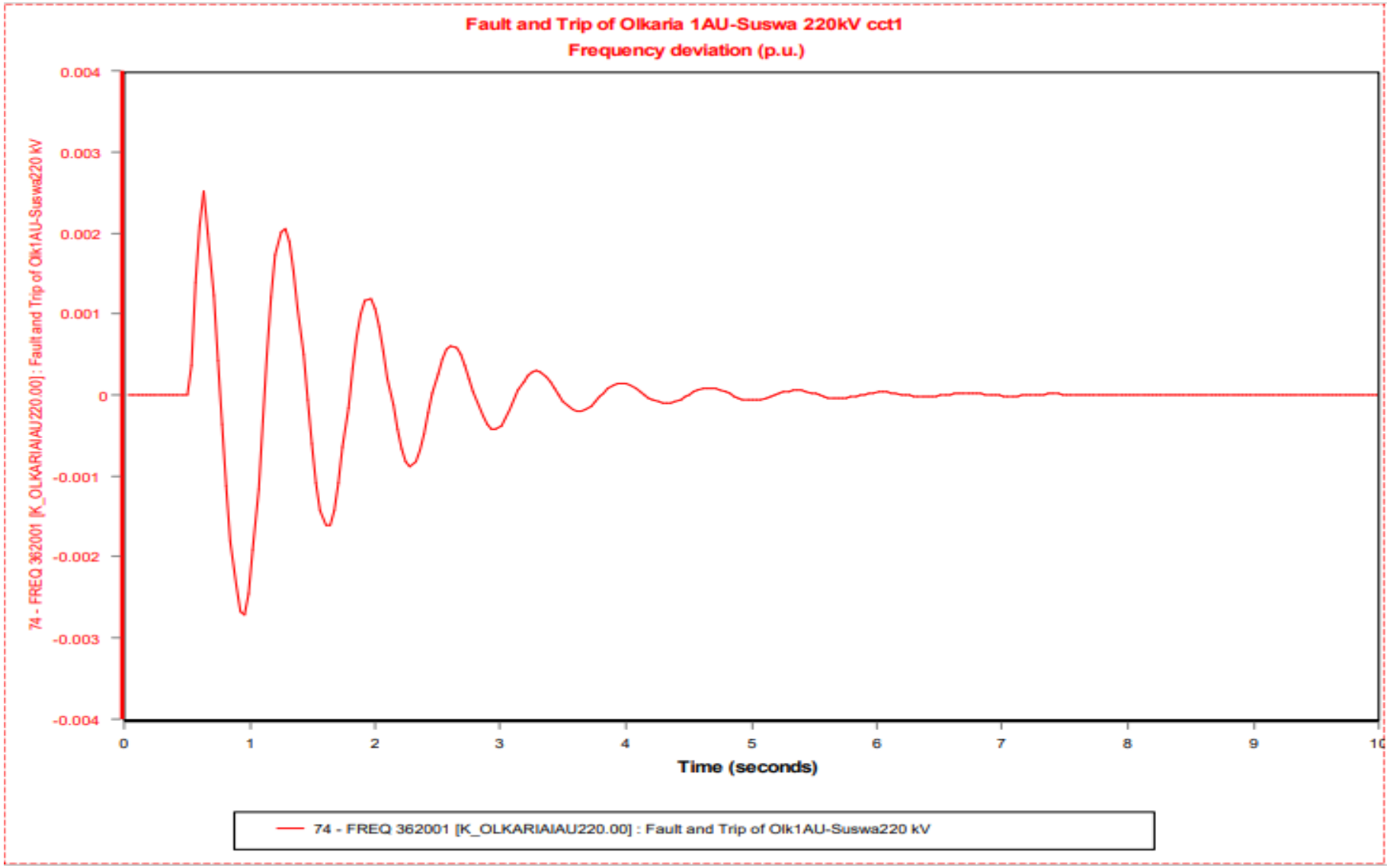


Figure 12. Three-phase fault on Olkaria-IAU – Suswa 220 kV line – Frequency response

6.3.2.3 Voltage response

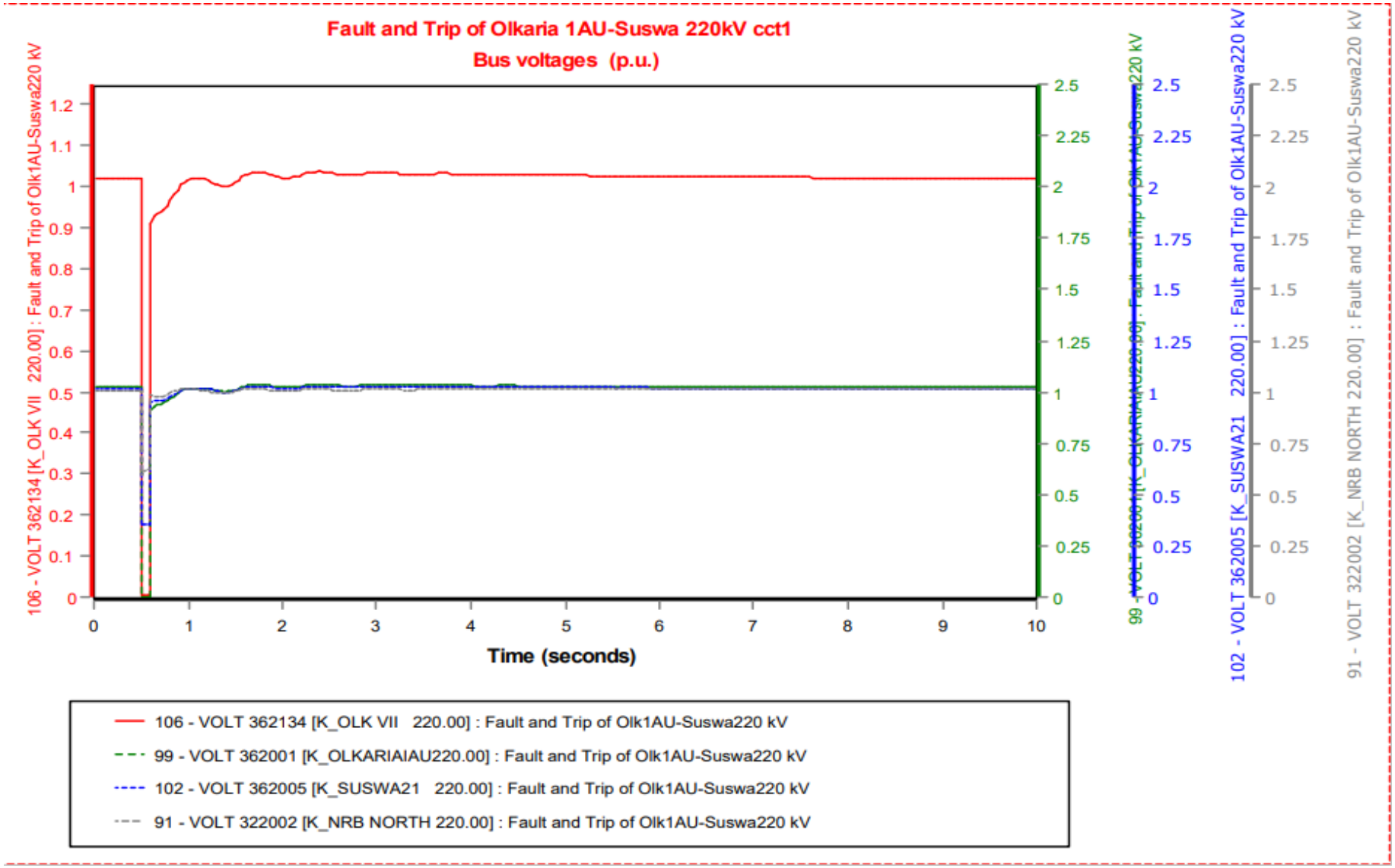


Figure 13. Three-phase fault on Olkaria-IAU – Suswa 220 kV line – Voltage response

6.3.2.4 Loading of Olkaria-IAU – Suswa 220 kV line cct 2 following the disturbance

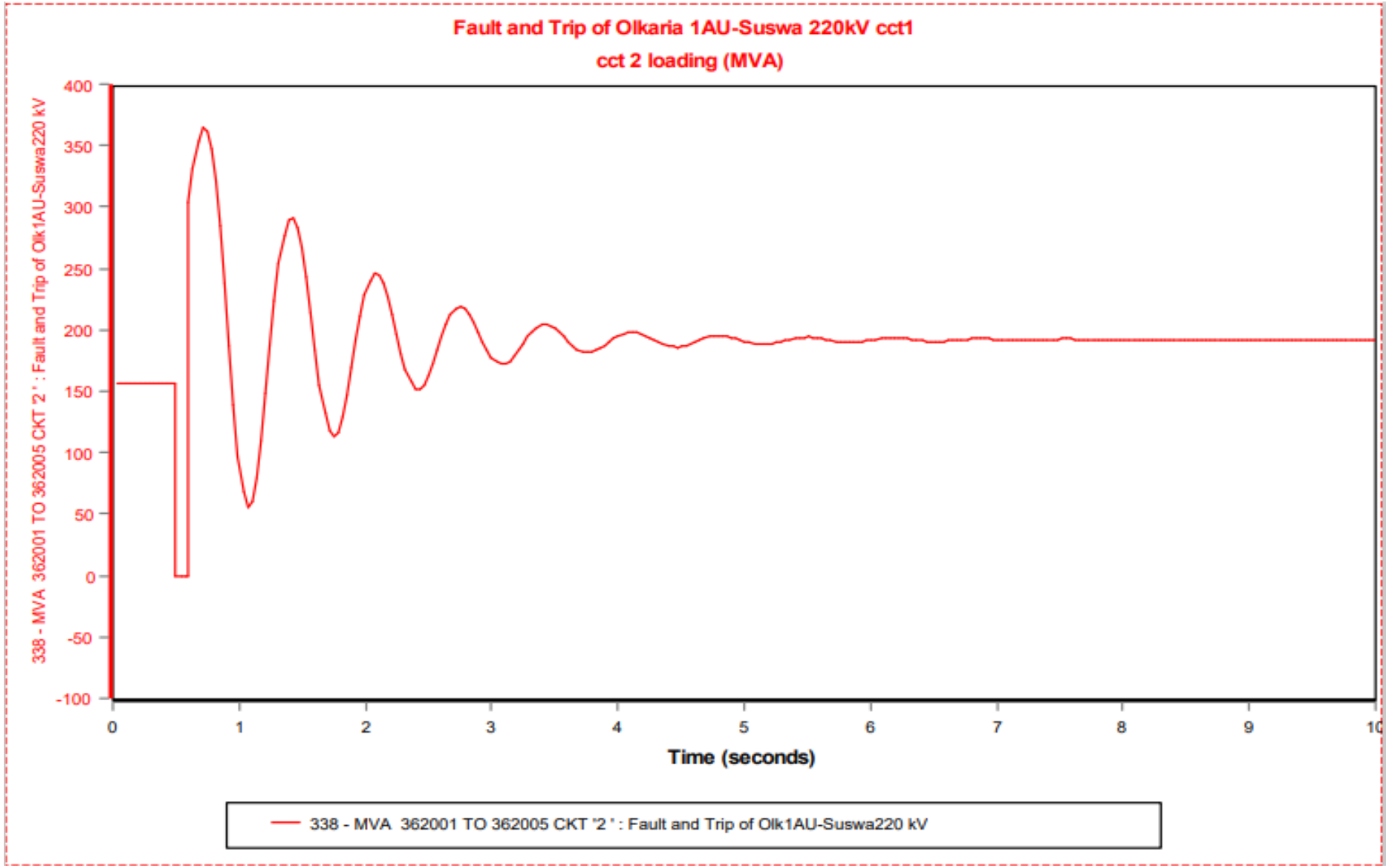


Figure 14. Loading of Olkaria-IAU – Suswa 220 kV line cct 2 following the disturbance

6.3.3 Three-phase fault and trip of Suswa – Nairobi North 220 kV line

6.3.3.1 Rotor angle response

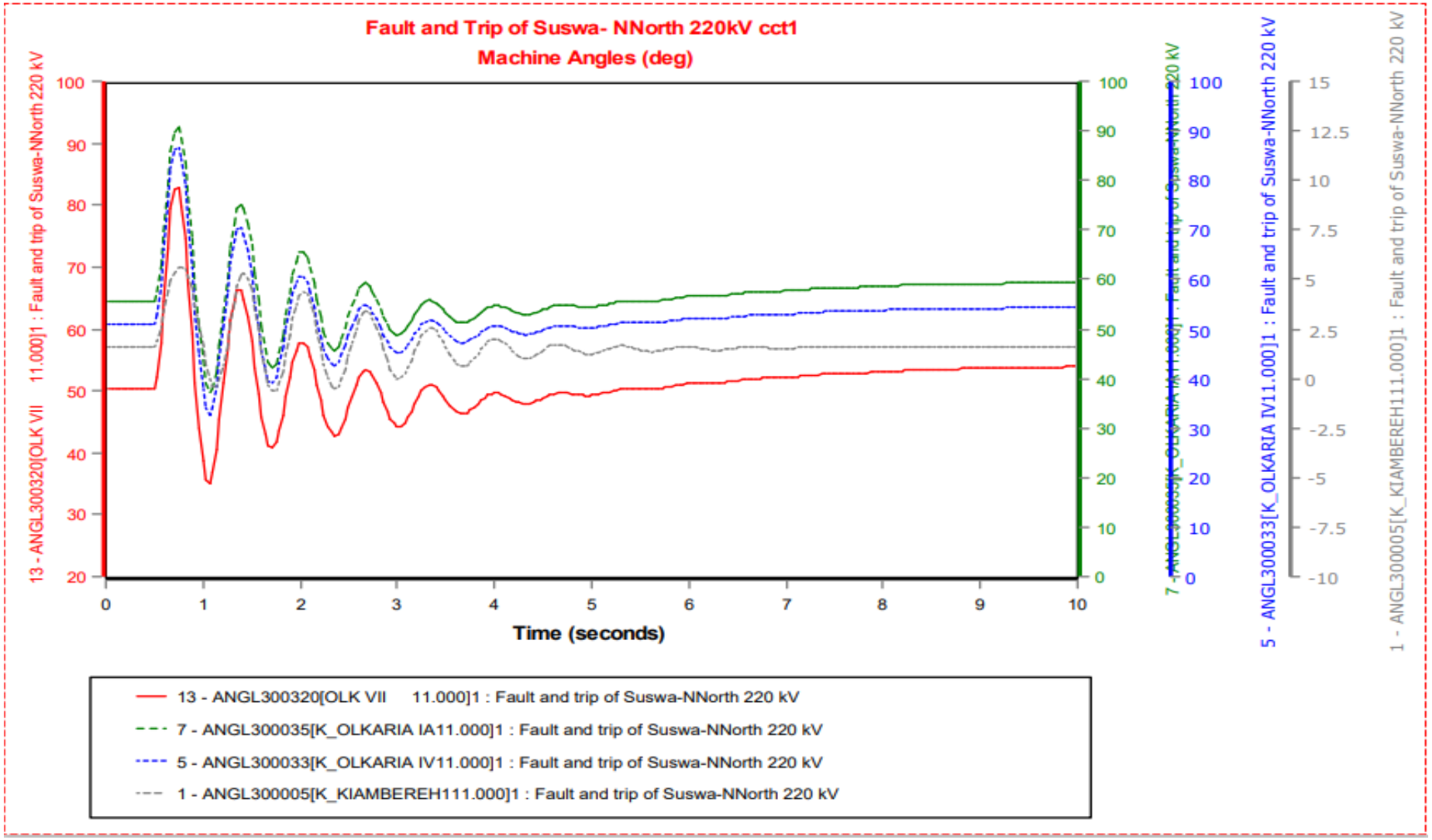


Figure 15. Three-phase fault and trip of Suswa – Nairobi North 220 kV line – Rotor Angle response

6.3.3.2 Frequency response

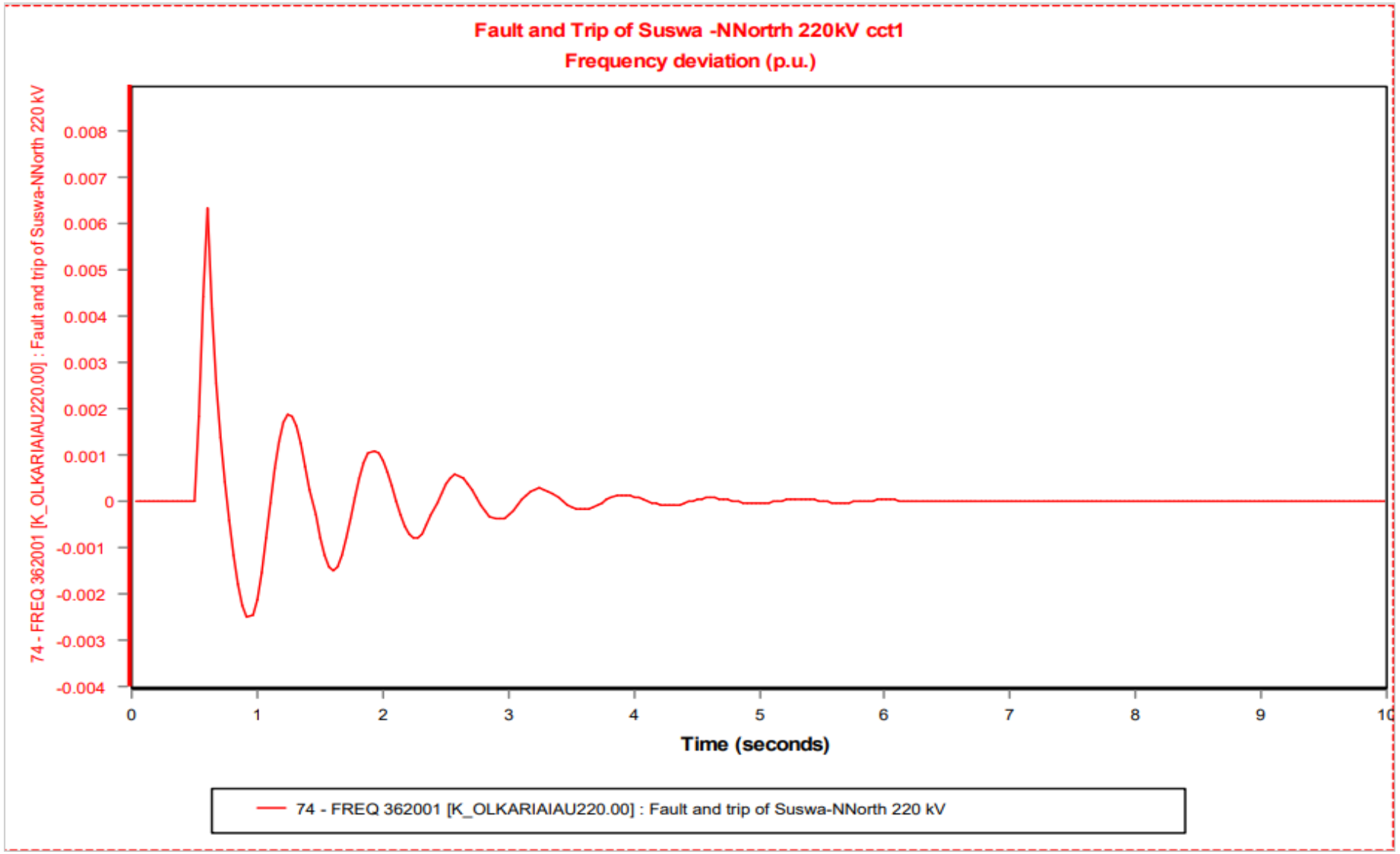


Figure 16. Three-phase fault and trip of Suswa – Nairobi North 220 kV line – Frequency response

6.3.3.3 Voltage response

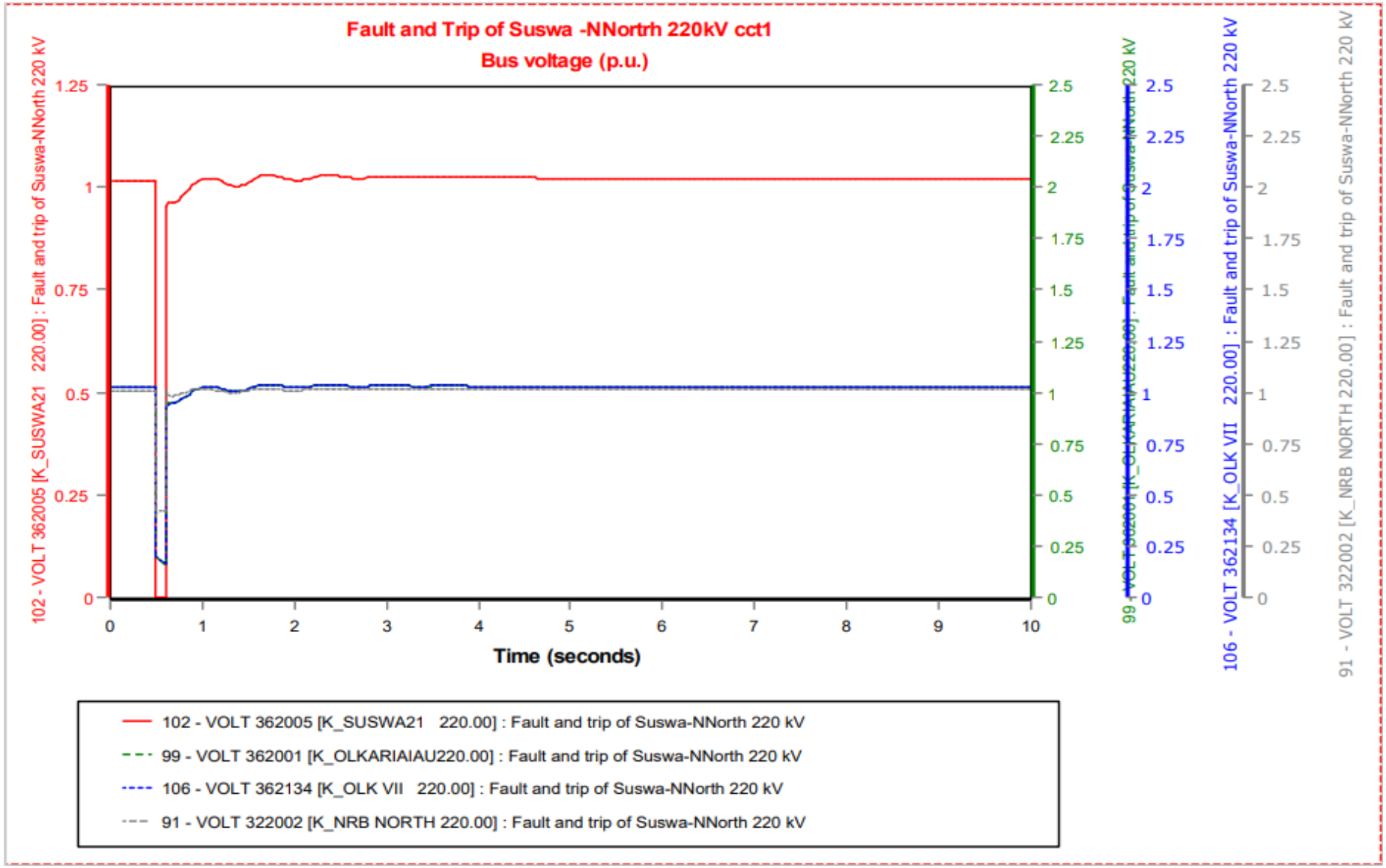


Figure 17. Three-phase fault and trip of Suswa – Nairobi North 220 kV line – Voltage response

6.3.4 175ms fault on Olkaria-VAU – Olkaria-IAU 220 kV line

6.3.4.1 Rotor angle response

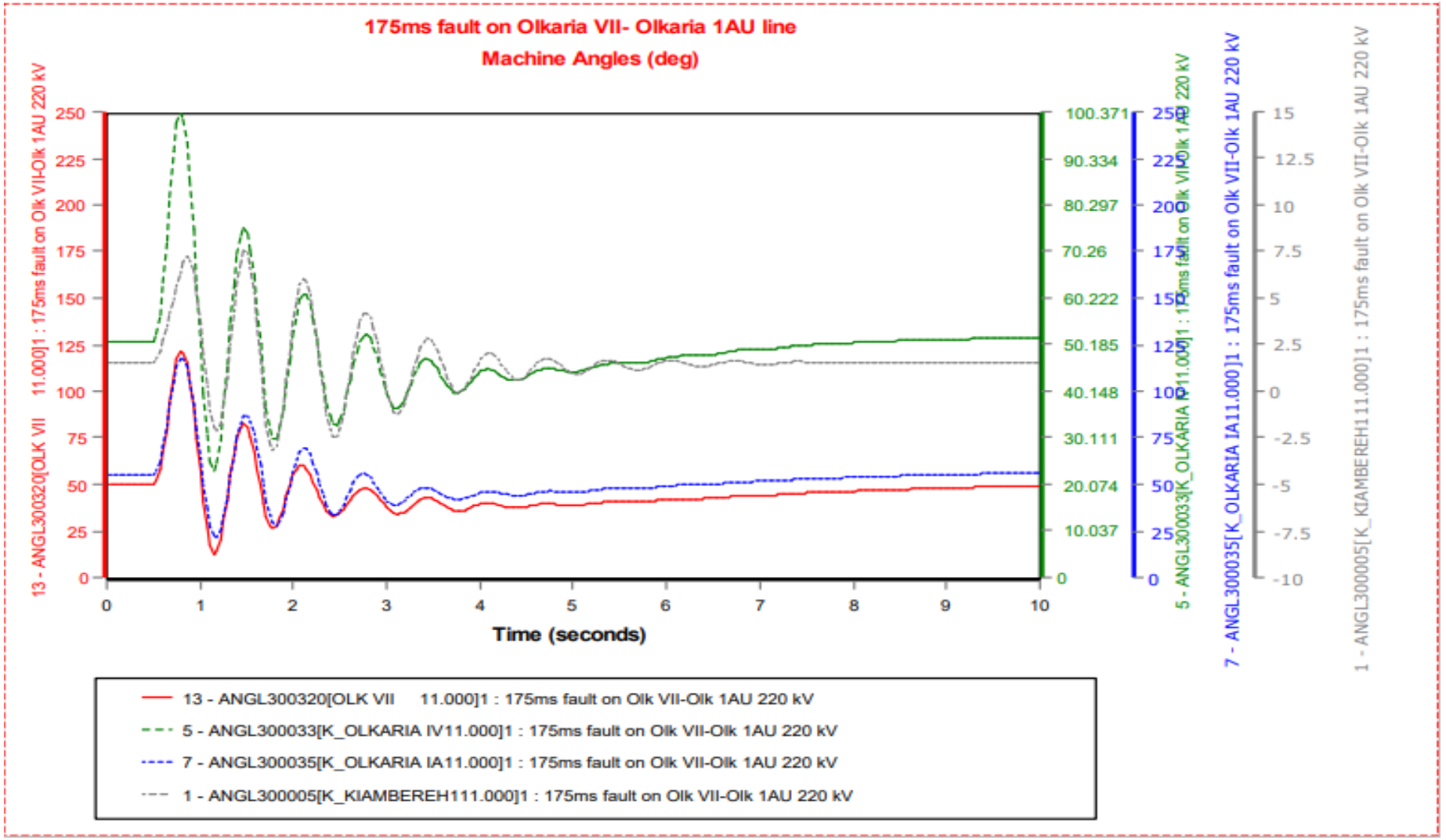


Figure 18. 175ms fault on Olkaria-VAU - Olkaria IAU 220 kV line – Rotor angle response

6.3.4.2 Frequency response

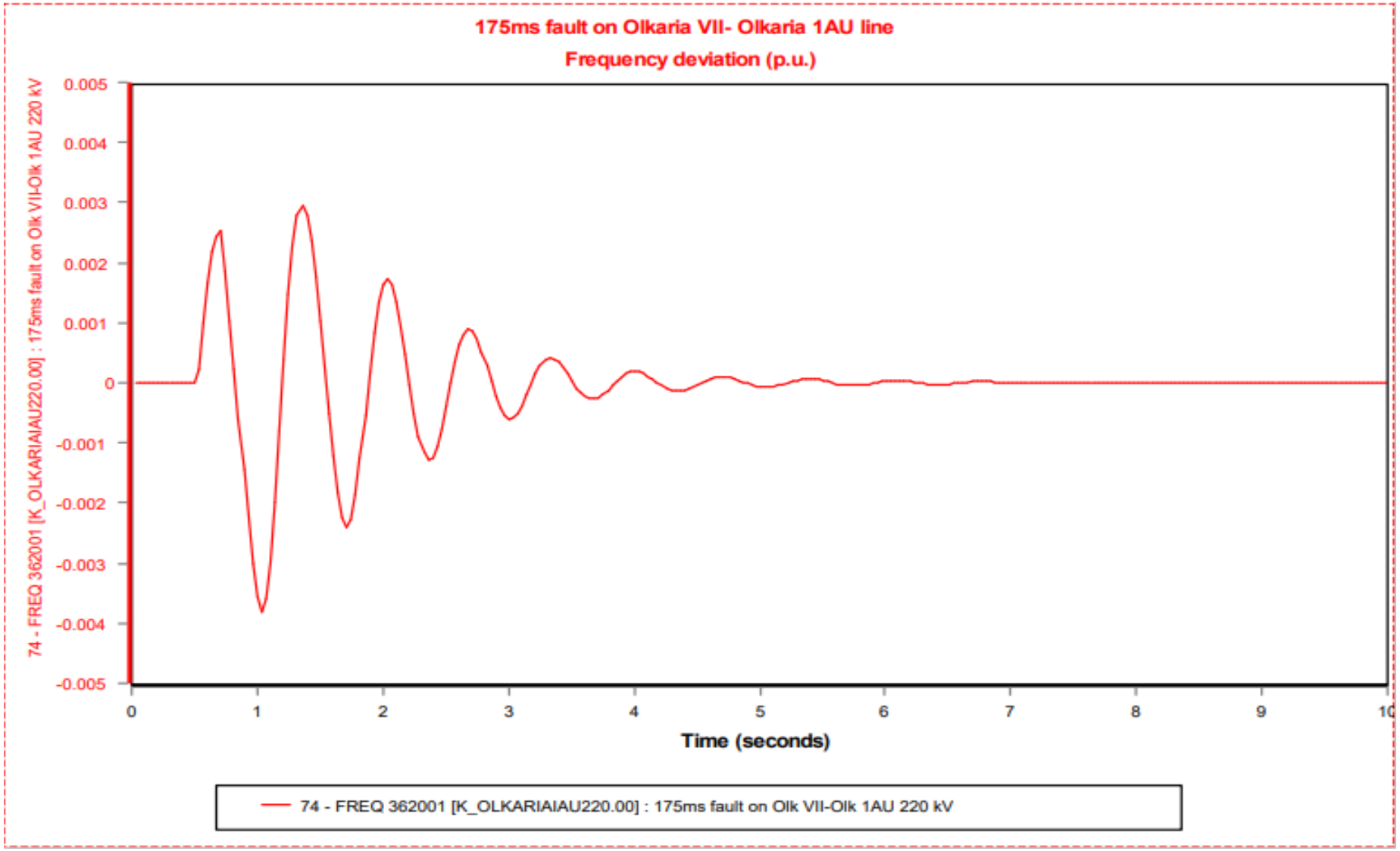


Figure 19. 175ms fault on Olkaria-VAU – Olkaria-IAU 220 kV line – Frequency response

6.3.4.3 Voltage response

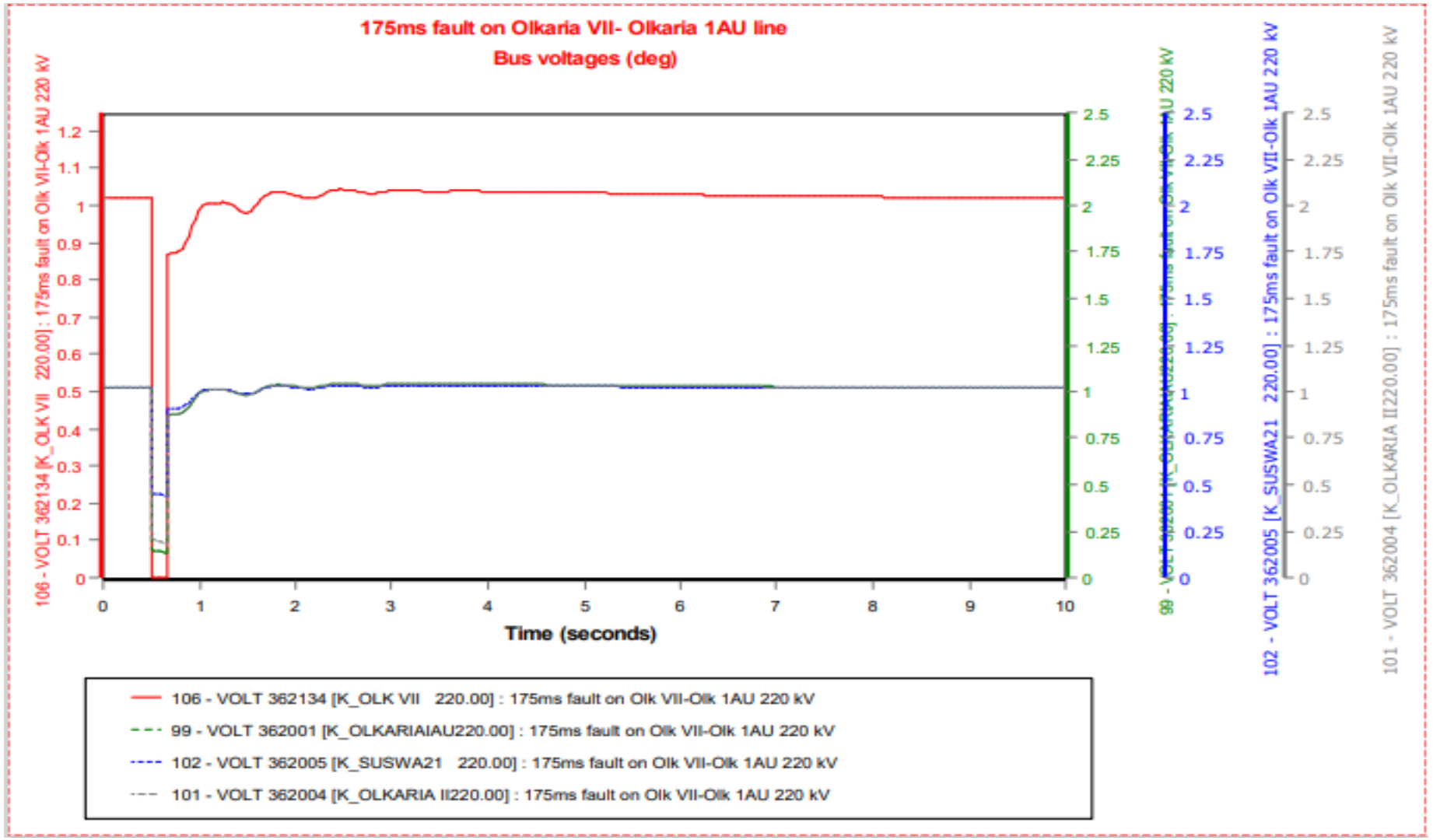


Figure 20. 175ms fault on Olkaria-VAU – Olkaria-IAU 220 kV line – Voltage response

6.3.4.4 Olkaria-VAU Generator Active and Reactive power genaration

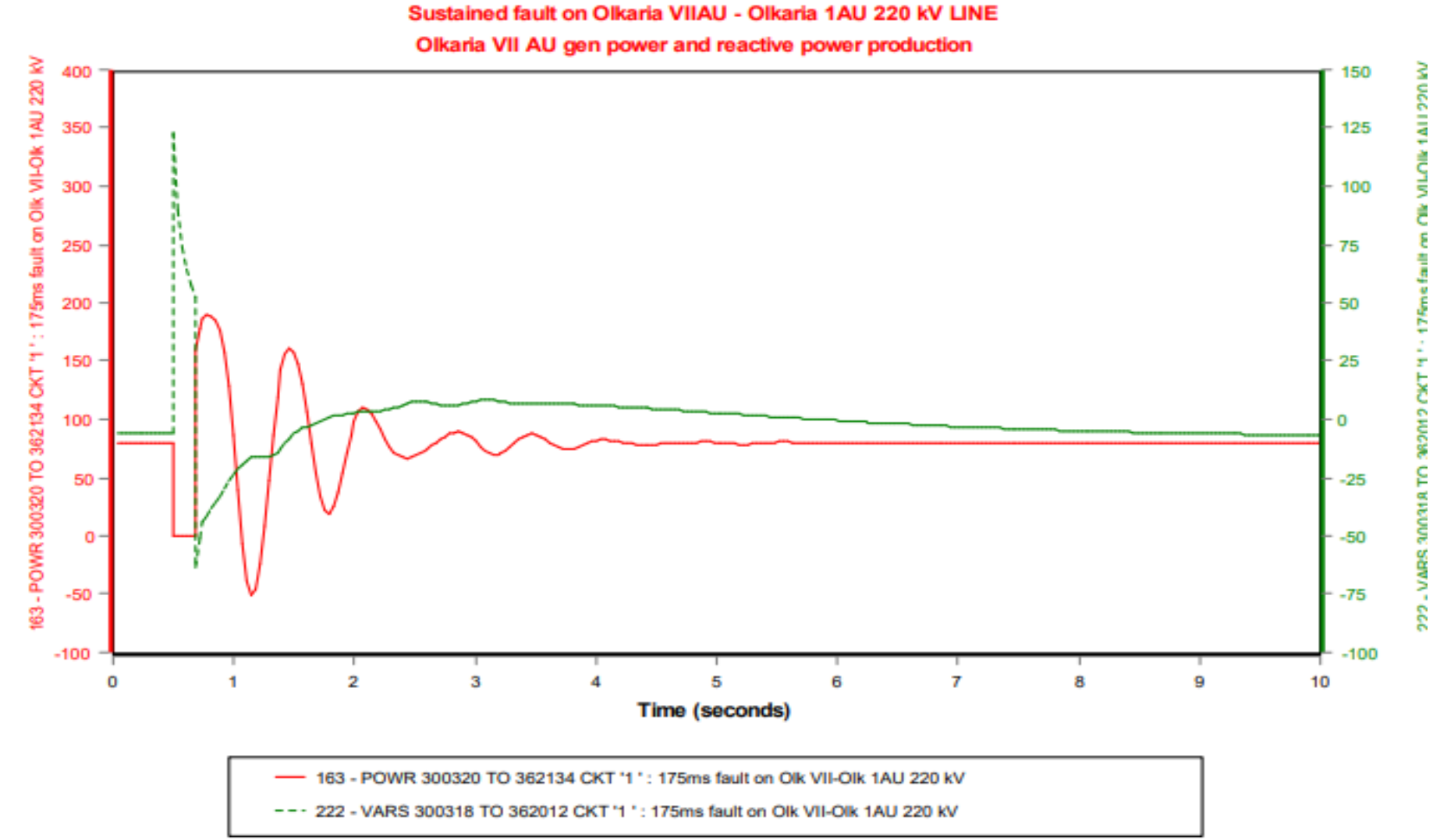


Figure 21. Olkaria-VAU Generator active and reactive power generation

6.3.5 Olkaria-VAU generator trip

6.3.5.1 Rotor angle response

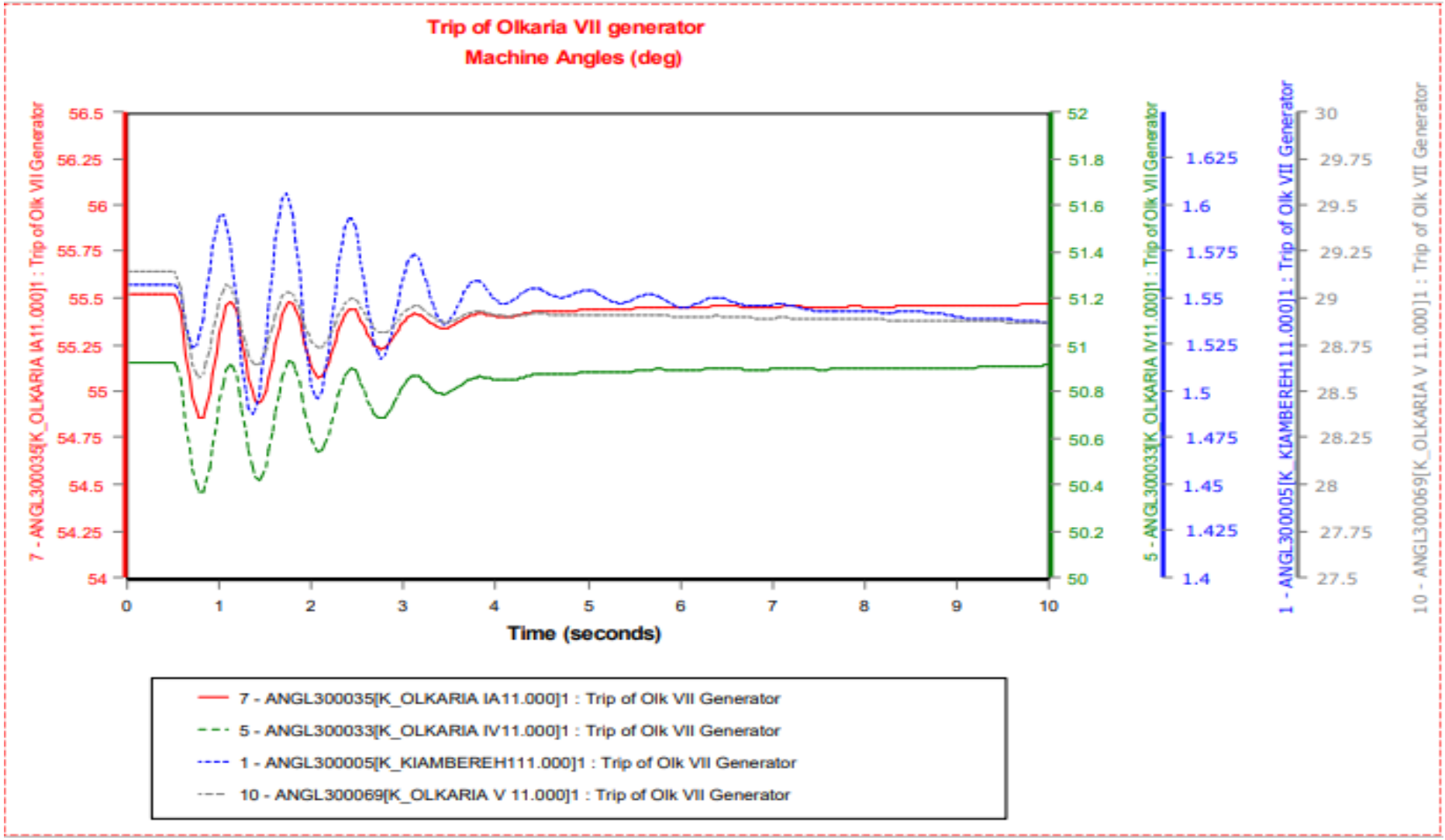


Figure 22. Olkaria-VAU generator trip – Rotor angle response

6.3.5.2 Frequency response

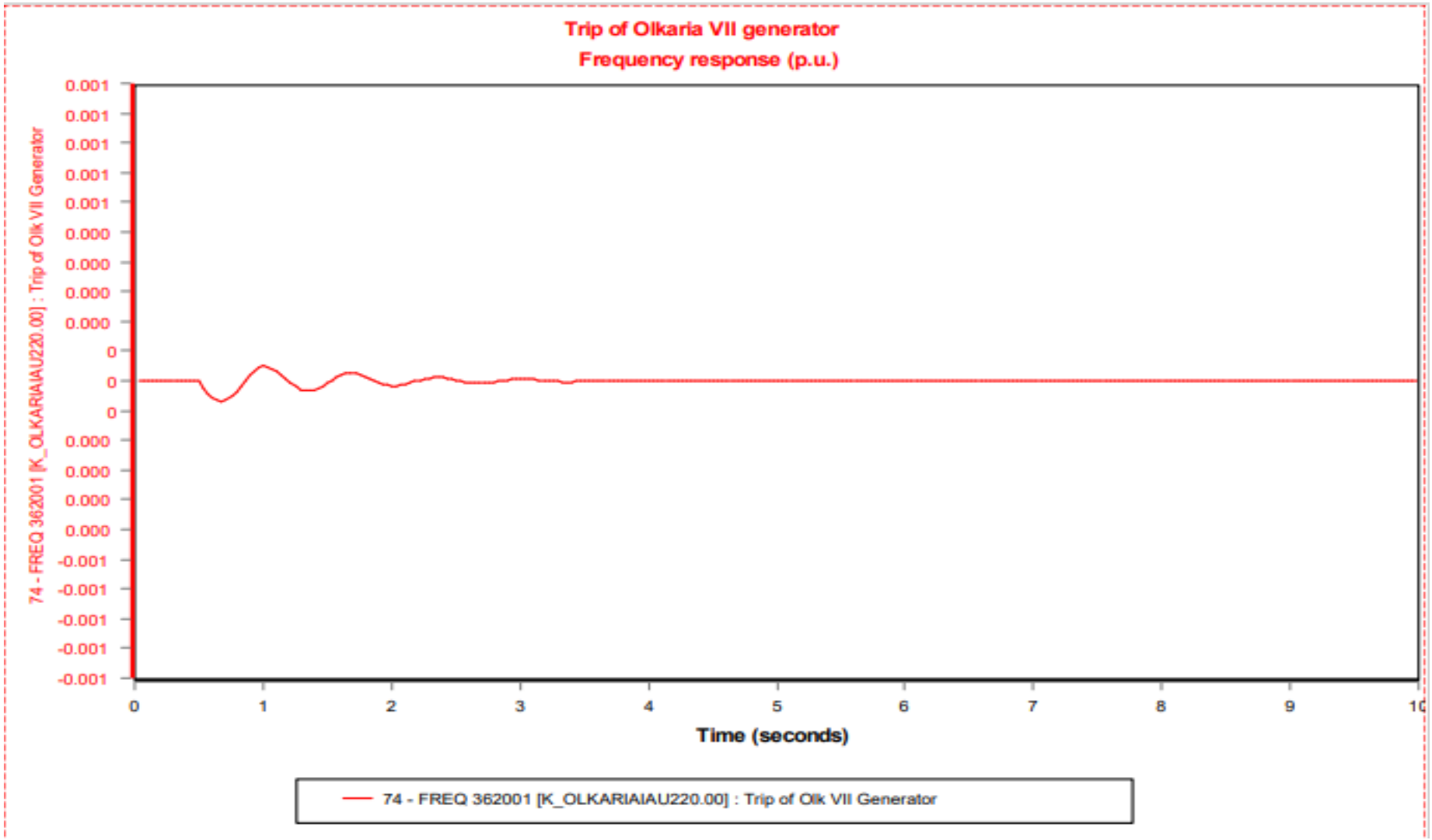


Figure 23. Olkaria-VAU generator trip – Frequency response

6.3.5.3 Voltage response

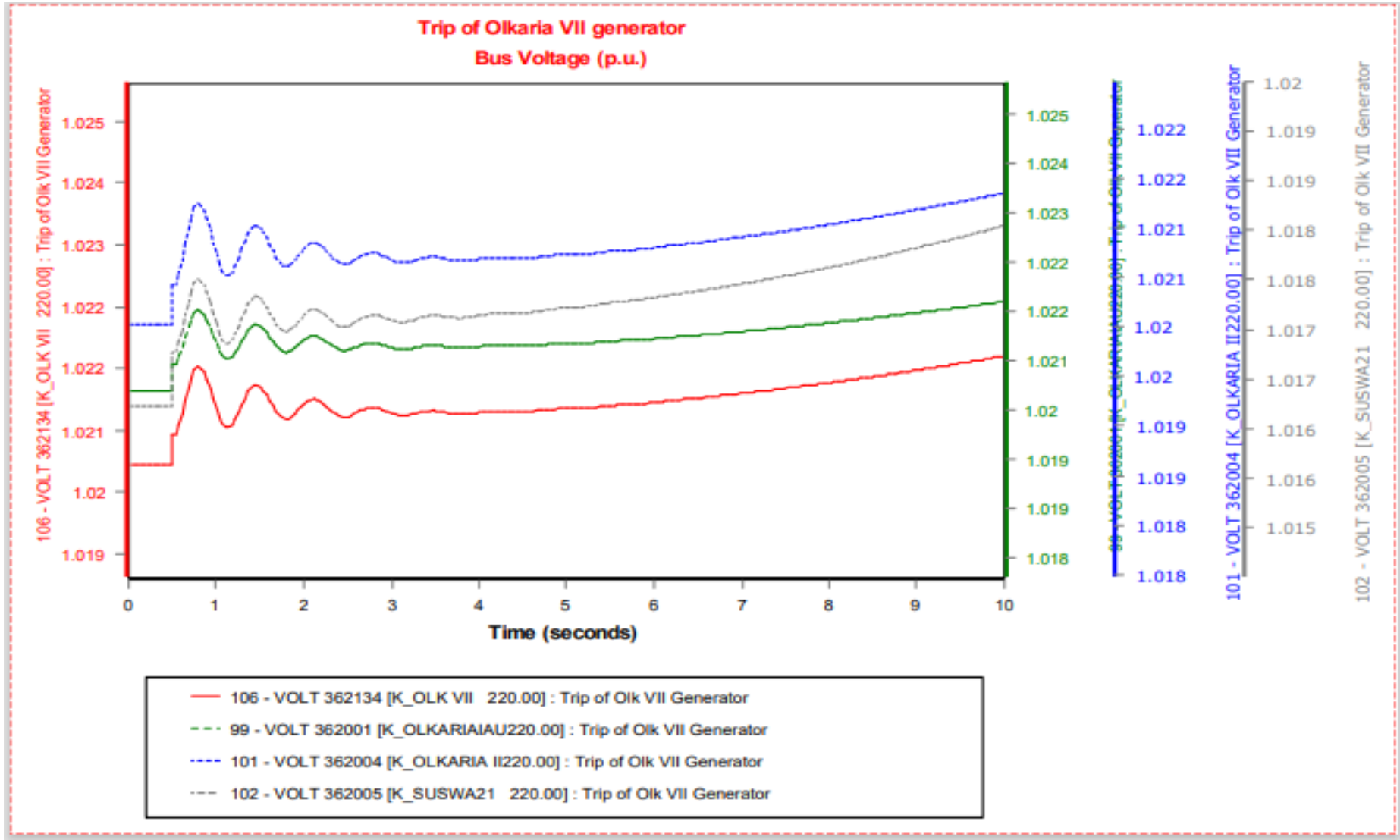


Figure 24. Olkaria-VAU generator trip – Voltage response

6.3.6 Trip of Olkaria-IAU Unit 6

6.3.6.1 Rotor angle response

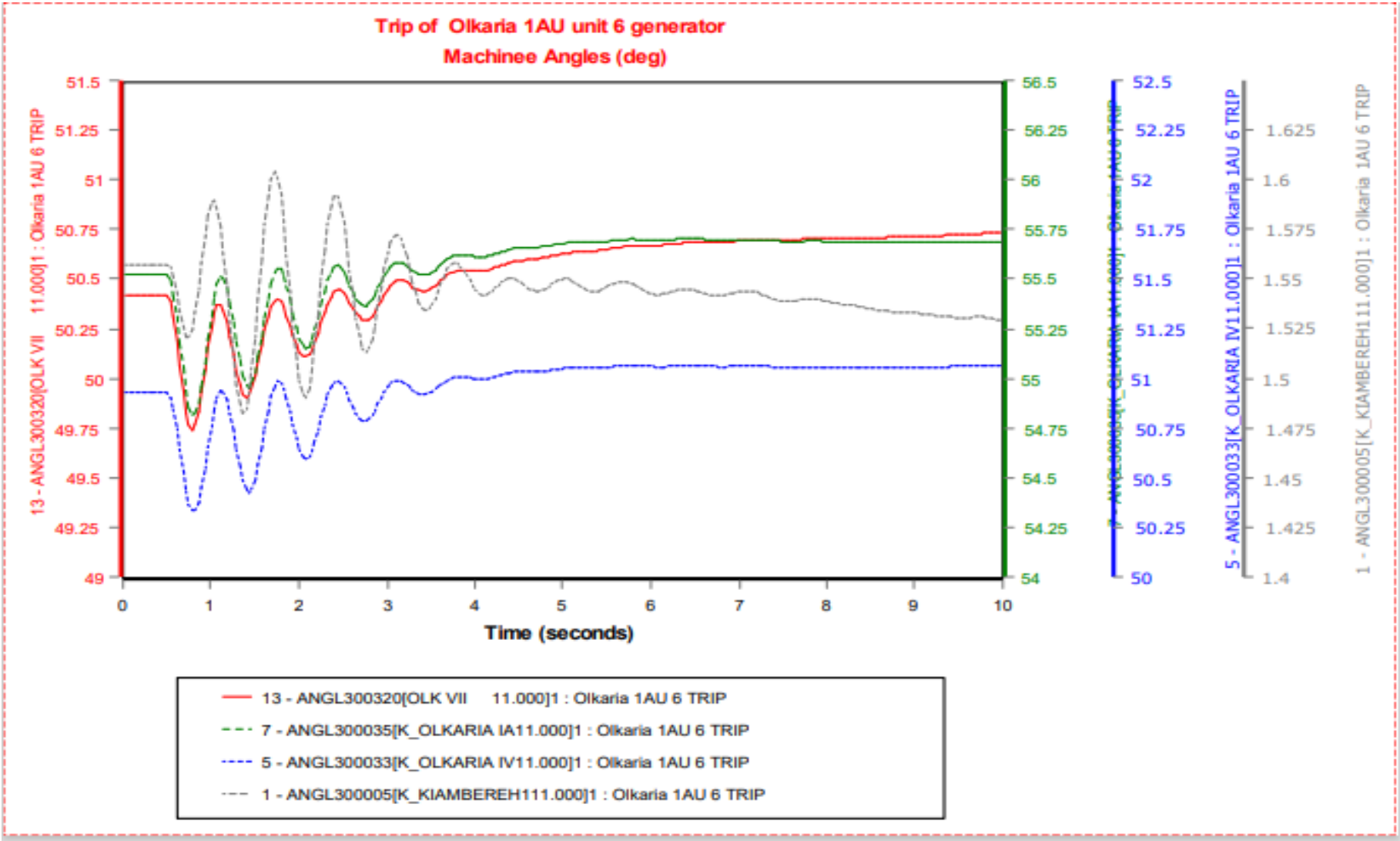


Figure 25. Trip of Olkaria-IAU Unit 6 – Rotor angle response

6.3.6.2 Frequency response

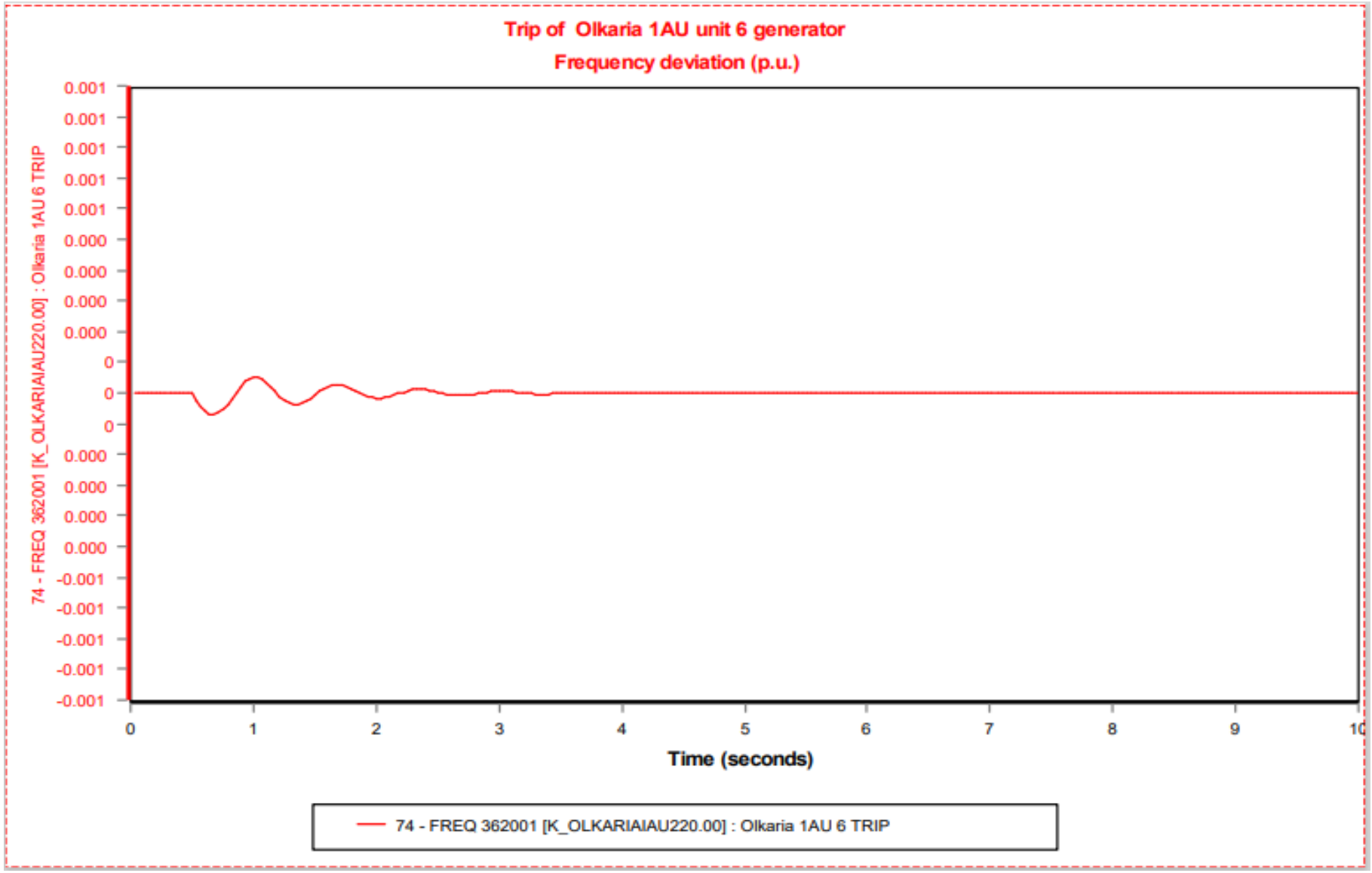


Figure 26. Trip of Olkaria-IAU Unit 6 – Frequency response

6.3.6.3 Voltage response

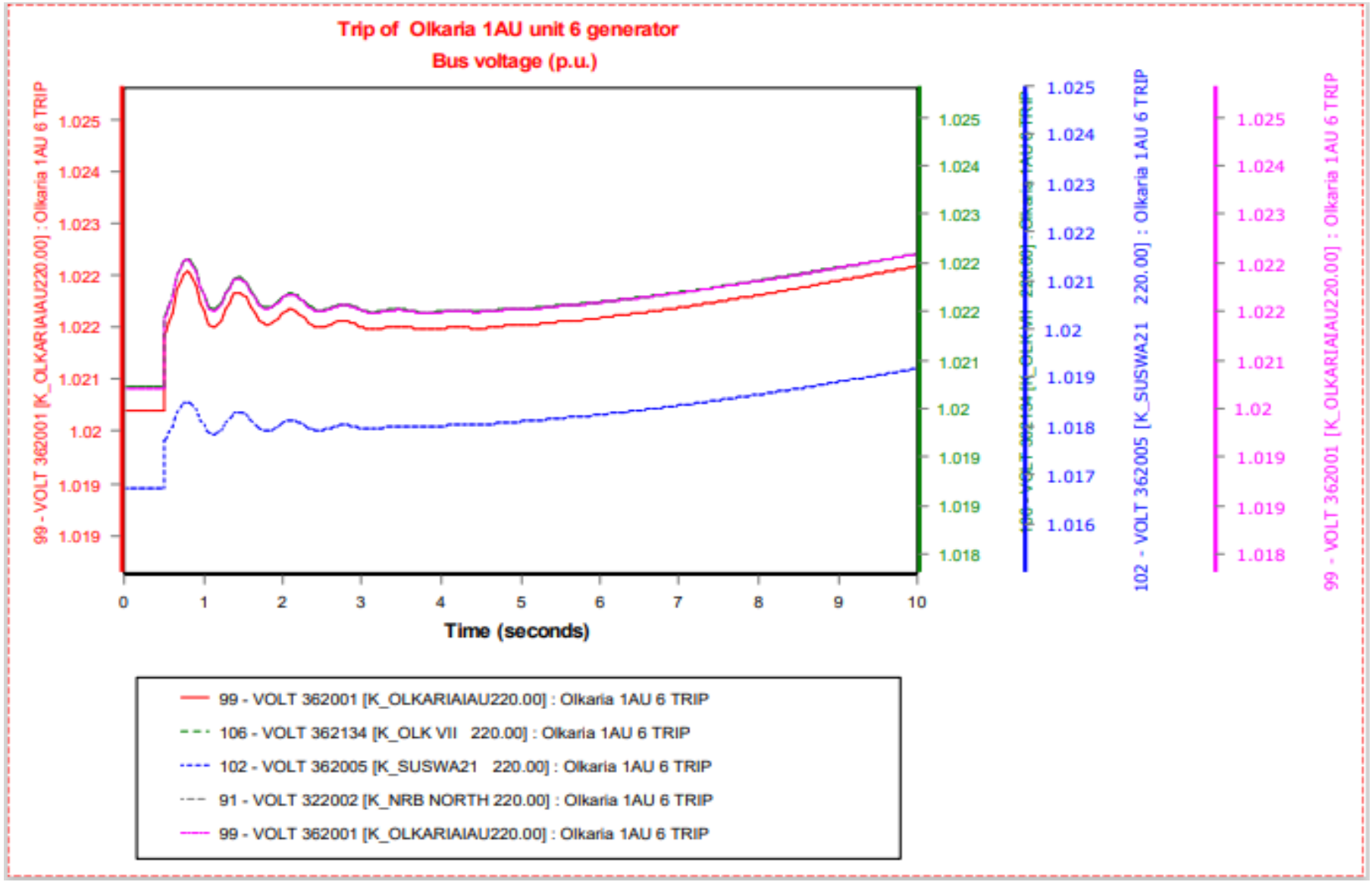


Figure 27. Trip of Olkaria-IAU Unit 6 – Voltage response

6.3.7 Trip of Olkaria-IAU plant

6.3.7.1 Rotor angle response

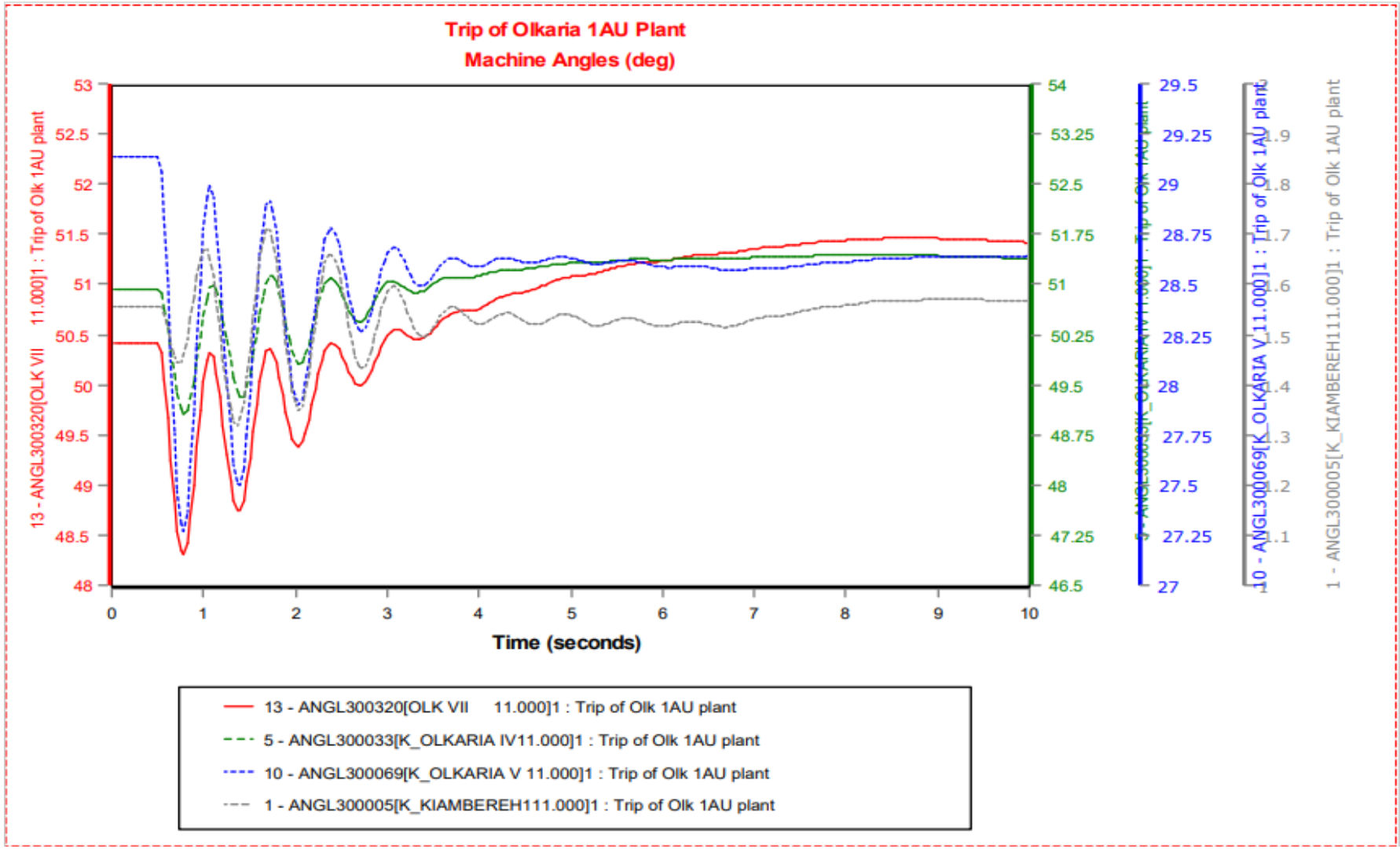


Figure 28. Trip of Olkaria-IAU plant – Rotor angle response

6.3.7.2 Frequency response

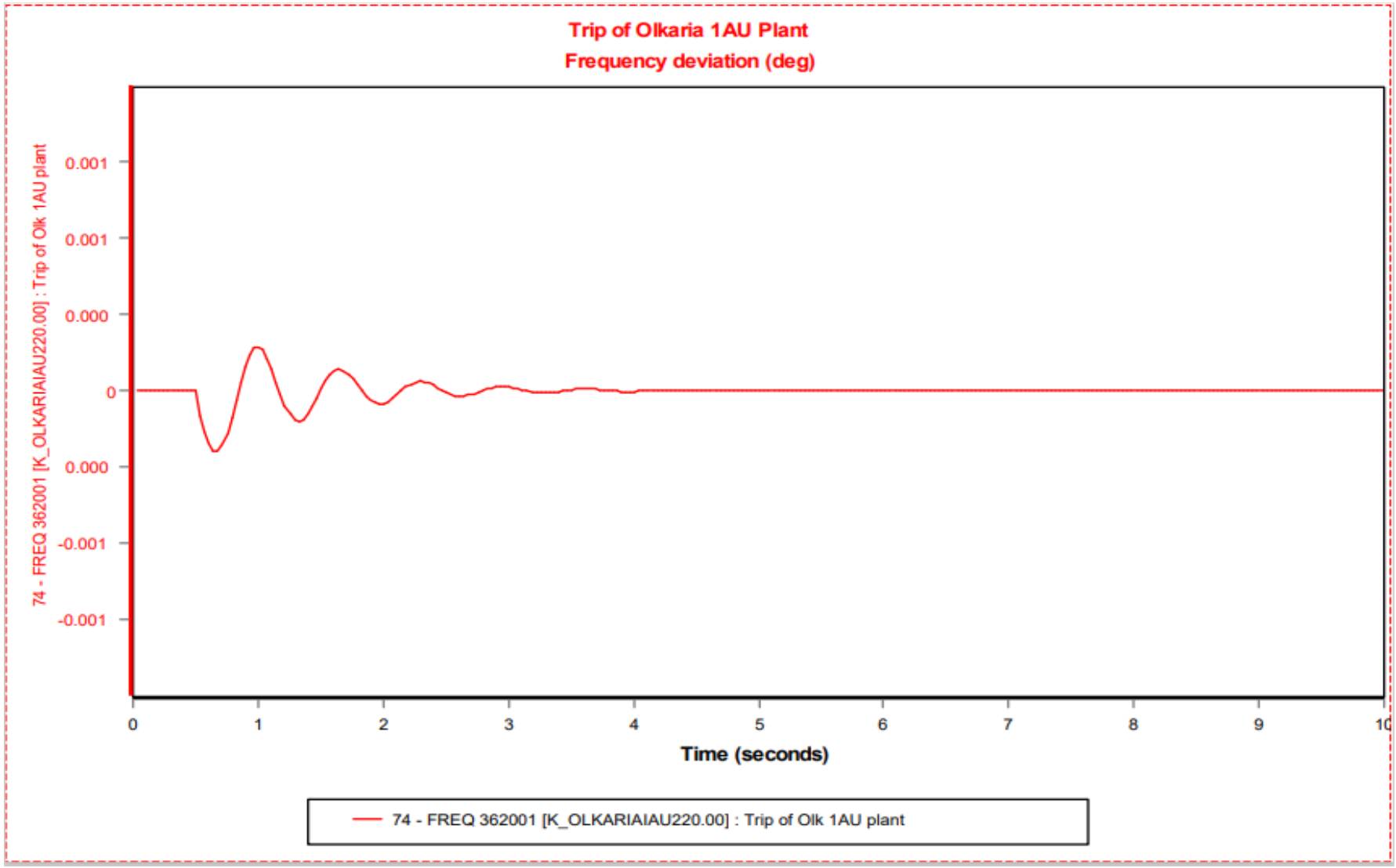


Figure 29. Trip of Olkaria-IAU plant – Frequency response

6.3.7.3 Voltage response

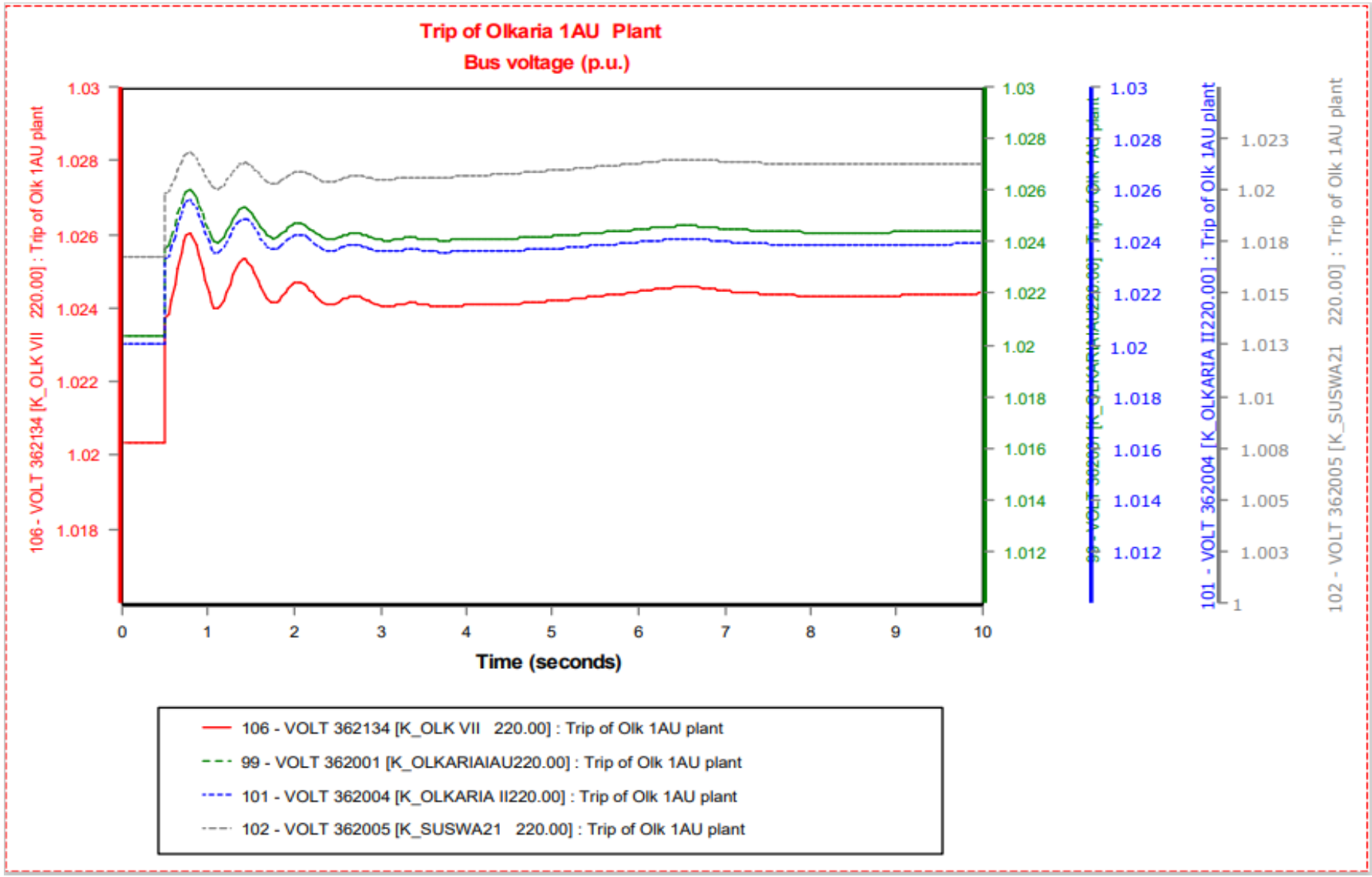


Figure 30. Trip of Olkaria-IAU plant – Voltage response

6.3.8 Fault and trip of Olkaria-III – Olkaria-II Extension 220 kV line

6.3.8.1 Rotor angle response

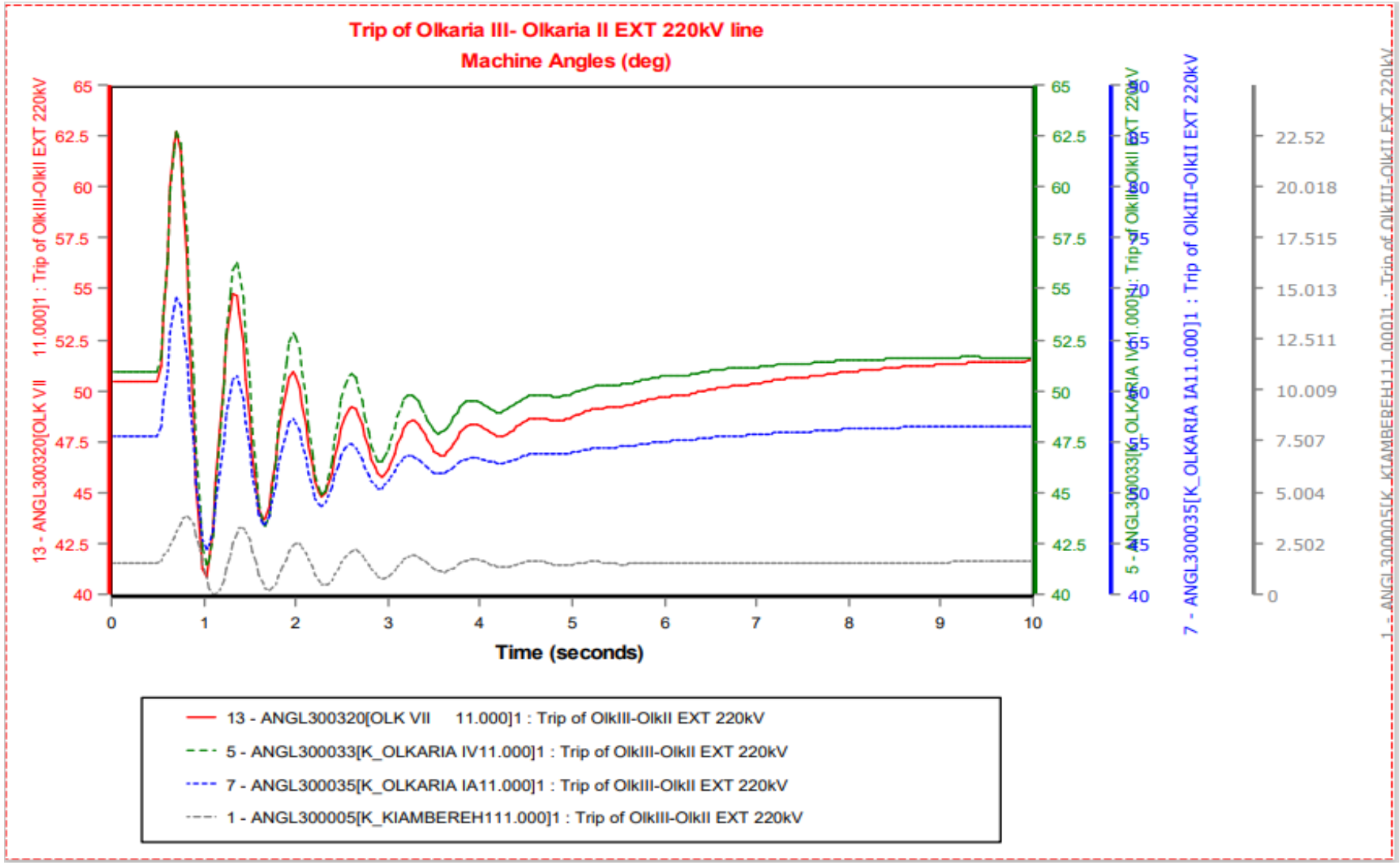


Figure 31. Fault and trip of Olkaria-III – Olkaria-II Extension 220 kV line – Rotor angle response

6.3.8.2 Frequency response

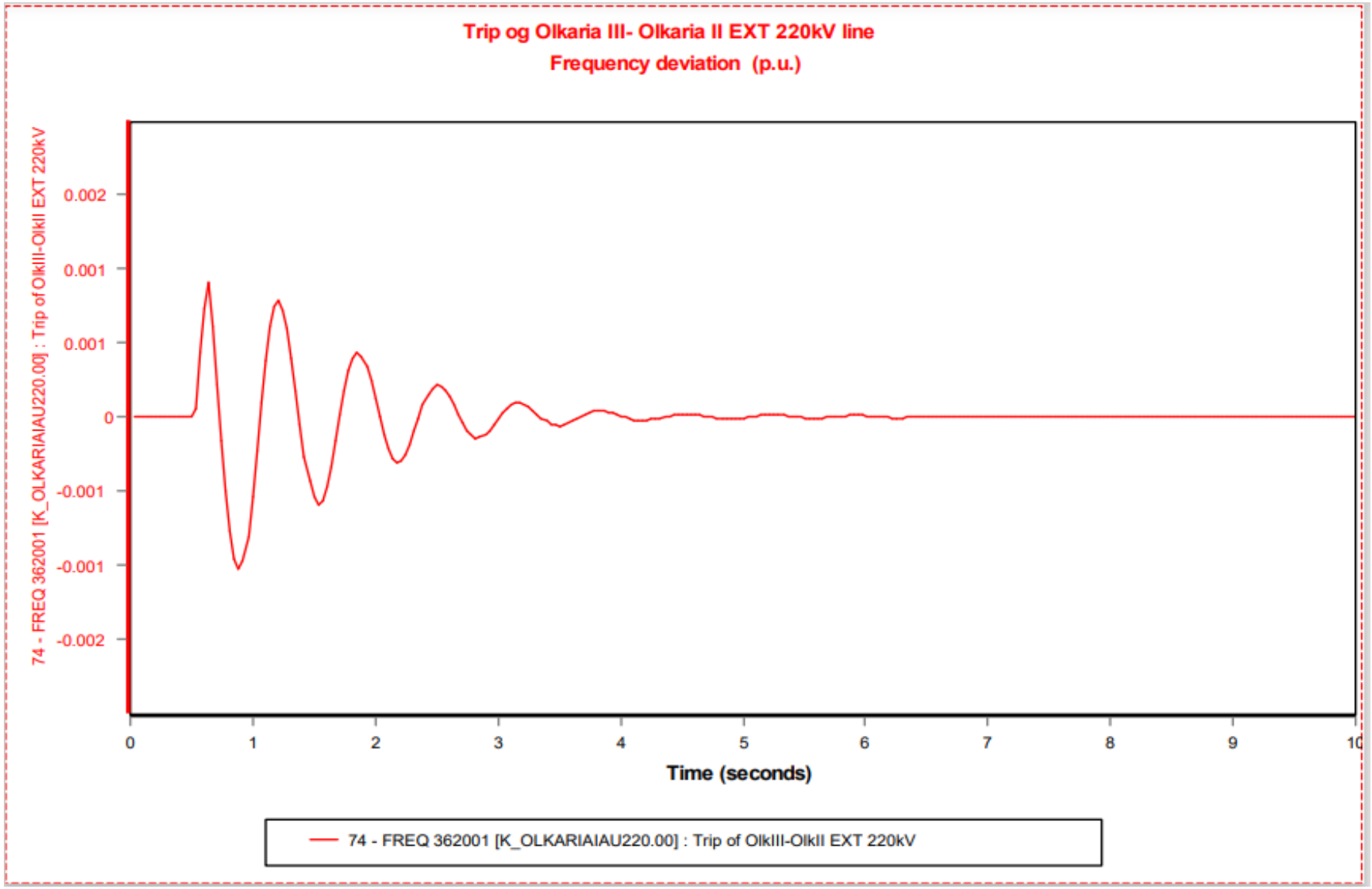


Figure 32. Fault and trip of Olkaria-III – Olkaria-II Extension 220 kV line – Frequency response

6.3.8.3 Voltage response

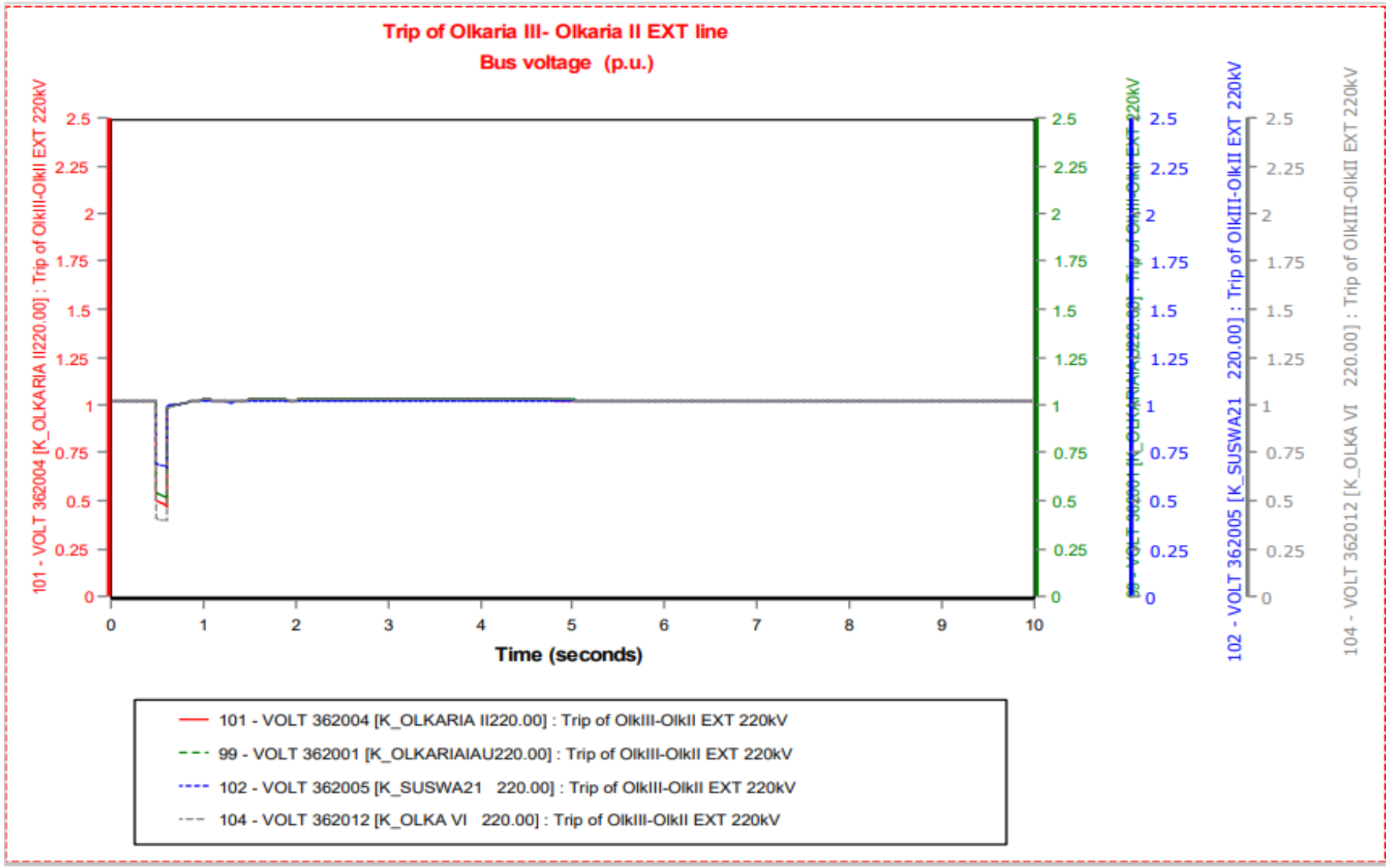


Figure 33. Fault and trip of Olkaria-III – Olkaria-II Extension 220 kV line – Voltage response

6.4 CONCLUSIONS

(i) Transient stability was established for all the disturbances simulated. In all cases, following a disturbance, machine rotor angles exhibit well dumped oscillations that die out within 3-4 seconds. Bus voltages and frequency recover to near the steady state values within 3 seconds. The different machines swing in the same direction indicating no loss of synchronism.

(ii) Three-phase short circuit fault disturbances result in the most significant rotor angle oscillations and frequency deviation compared to loss of generation disturbances. The worst-case frequency deviation, 0.006 p.u. or 0.3 Hz, occurs in the case of three-phase fault and trip of one of the Suswa-Nairobi North 220 kV lines

(iii) A sustained fault on the transmission line evacuating the new power plant cleared in 175ms and does not result in loss of synchronism for the new generator. Rotor angle and frequency oscillations die out within 4 seconds and voltage recovers to initial value within 3 seconds. I addition, the generator active and reactive power output stabilizes within 4 seconds and recovers to pre disturbance values within 10 seconds.

7 ATTACHMENTS

ATTACHMENT-1: Base Case, 2027 Peak Dispatch

POWER PLANT	Power Generation (MW)	Maximum Power (MW)
ETHIOPIA POWER	600.7	600.7
LTWP	250.0	310.0
KINDARUMA	10.0	24.0
GITARU	42.6	72.5
KAMBURU	20.0	31.5
MASINGA	10.0	40.0
KIAMBERE	60.0	164.0
TURKWEL	40.0	106.0
OLKARIA-I G1	63.0	63.0
KIPEVU III	51.0	115.0
IBERAFRICA	8.0	52.5
MENENGAI-I	105.0	105.0
OLKARIA-II G1	90.0	105.0
OLKARIA-III	143.0	150.0
OLKARIA-IV	160.0	170.0
OLKARIA-IAU	241.0	253.0
RABAI POWER	18.0	90.0
SONDU	60.0	60.0
SANGORO	19.0	20.0
KWALE SUGAR	10.0	18.0
TANA	14.0	21.0
THIKA MSD	35.2	87.0
NGONG WI	4.4	25.5
NAIVASHA	9.2	14.8
WELLHEAD 37	20.0	33.8
OLKARIA-V	160.0	170.0
7FOLKS SOLAR	0.0	40.0
EMBAKASI BESS	25.0	100.0
OLK II EXT	140.0	150.0
SUNPOWER	0.0	40.0
KIPETO	70.0	100.0
CHANIA	12.5	50.0
DWA KIBOKO	0.7	1.4
ISINYA	0.0	10.0
PRUNUS	12.5	50.0
APERTURE GREEN	12.5	50.0
KENSEN	0.0	40.0
GARSEN	10.0	20.0
MERU 33	0.4	1.6
KIGANJO 33	3.9	11.1
KUTUS 33	1.7	6.8
KYENI 33	1.8	7.1
SUSWA BESS	25.0	100.0
CHEMOSIT	0.4	0.9
KENERGY	0.0	40.0
KISII BESS	25.0	50.0
KISUMU	0.6	2.4
MUSAGA	1.3	5.2
KISII 132	0.1	0.5
LESSOS BESS	25.0	100.0
BARINGO	100.0	100.0
TARITA	0.0	40.0
UGANDA POWER	4.0	100.0
TOTAL	2716.6	4119.3

End of

Grid Stability Report

ANNEX-III

LIST OF COLLECTED INFORMATION

APPENDIX III-1

LIST OF COLLECTED INFORMATION

List of main information and data collected for the development of the Project. Most of the information and data was sourced directly from KenGen personnel and the rest was collected at the time of the field surveys implemented by the Study Team.

Information and data collected for Study development	
No	**Kenya Energy Market and Geothermal Field surface installations**
1	Olkaria-VII Feasibility Study, complete
2	Olkaria-VII ESIA Study, complete
3	List of power generation projects by KenGen to be commissioned until 2030 (detailing gross output and expected net average output) including thermal, geothermal, hydro, wind, solar and from other source, if any)
4	Development of a Power Generation and Transmission Master Plan, Kenya Long Term Plan 2015-2035 by Lahmeyer
5	Development of a Power Generation and Transmission Master Plan, Medium Term Plan 2015-2020 by Lahmeyer
6	Development of a Power Generation and Transmission Master Plan, Medium Term Plan 2020-2025 by Lahmeyer
7	Latest Approved Least cost Power Development Plan (LCPDP)
8	Latest list of committed projects
9	Planned installed power generation capacity as per Kenya vision 2030
10	KPLC Annual Reports 2023, 2022, 2018, 2014,
11	KPLC Annual Load Curve 2023 data
No	**Environmental & Social Impact Assessment for Olkaria V-AU**
1	Kenya Electricity Generating Company Plc 80.3Mwe Olkaria-VII Geothermal Power Plant Environmental and Social Impact Assessment Study Report
2	Noise Impact Assessment Report The Proposed Olkaria-VII Geothermal Power Plant
3	Environmental and Social Impact Assessment Project Report for the Proposed 140 Mwe Olkaria-V Geothermal Power Plant
4	Self Environmental Audit Report for Olkaria V Geothermal Power Station, 2022
5	The Environmental Management and Co-Ordination Act License to Transport Waste
6	National Environment Management Authority (NEMA) The Environmental Management And Co-Ordination Act Environmental Impact Assessment License
7	Environmental Management at Olkaria Geothermal Project Annual Report For Fy 2015/16 (July 2015 – June 2016)
8	Environment & Liaison-Geothermal Annual Environment Annual Report July 2021-June 2022

End of Annex

ANNEX-IV

Kenya Electricity Generating Company Plc

80.3MWe Olkaria-VII

Geothermal Power Plant

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

STUDY REPORT

ADDENDUM

THIS ADDENDUM COVERS:

1 STATUS OF FIVE CONDITIONS OF INTERNATIONAL FINANCE CORPORATION FOR THE PROJECT IN NATIONAL PARKS 1
[ADDENDUM TO “4. BASELINE INFORMATION OF THE PROJECT AREA”]

2 ALTERNATIVE POWER GENERATION SYSTEM 6
[ADDENDUM TO “2.8. ANALYSIS OF ALTERNATIVES”]

3 SCOPING 15
[ADDENDUM TO “4. BASELINE INFORMATION OF THE PROJECT AREA”]

4 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT MATRIX 27
[ADDENDUM TO “7. POSITIVE IMPACTS OF THE PROPOSED PROJECT” AND “8 NEGATIVE IMPACTS OF THE PROPOSED PROJECT”]

5 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP) 38
[ADDENDUM TO “10. PROPOSED ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN”]

6 ENVIRONMENTAL MONITORING PLAN (EMOP) 46
[ADDENDUM TO “11. ENVIRONMENTAL AND SOCIAL MONITORING PLAN’]

7 RESULT OF THE MEETING WITH THE MAASAI PEOPLE HELD BY JICA’S STUDY TEAM IN JULY 2024 60
[ADDENDUM TO “6. STAKEHOLDER CONSULTATIONS AND PUBLIC PARTICIPATION”]

8 GRIEVANCE REDRESS MECHANISM 61
[ADDENDUM TO “6.5. GRIEVANCE REDRESS MECHANISM”]

This Addendum has been prepared to eliminate the gap between the 80.3MWe Olkaria VII Geothermal Power Plant Environmental and Social Impact Assessment Study Report (ESIA) and the Environmental and Social Considerations Guidelines of JICA.

1 STATUS OF FIVE CONDITIONS OF INTERNATIONAL FINANCE CORPORATION FOR THE PROJECT IN NATIONAL PARKS

A part of the northern side of the project site includes Hell's Gate National Park. The location planned for the Olkaria VAU power plant is outside the national park, and KenGen is independently proceeding with well drilling within the project site. There are 19 production wells and 7 reinjection wells drilled in the past and which were assigned to the Olkaria V Additional Unit Project. However, since two of those wells, OW-39 and OW-39B, are located within the Olkaria National Park, their utilization was dismissed due environmental considerations. In order to replace the steam output, one (1) additional production well, OW-48B, recently drilled outside the national park, has been assigned to the Olkaria V Additional Unit Project.

The planned transmission line for this project will be 220kV, connecting the Olkaria VAU to the existing Olkaria IAU Substation, with an approximate distance of 2.7 km. As the Olkaria IAU Substation is located within the national park, the plan is for a portion of the transmission line (approximately 0.75 km) to pass through the national park. The route has been designed to avoid the power plant's vent station and the white plume discharged from its cooling tower and containing H_2S. Additionally, it follows existing roads and minimizes impact on Hell's Gate National Park wherever possible.

As part of the project is implemented in a national park, the status of the five conditions, referencing JICA Environmental and Social Guidelines based on IFC regulations are described below.

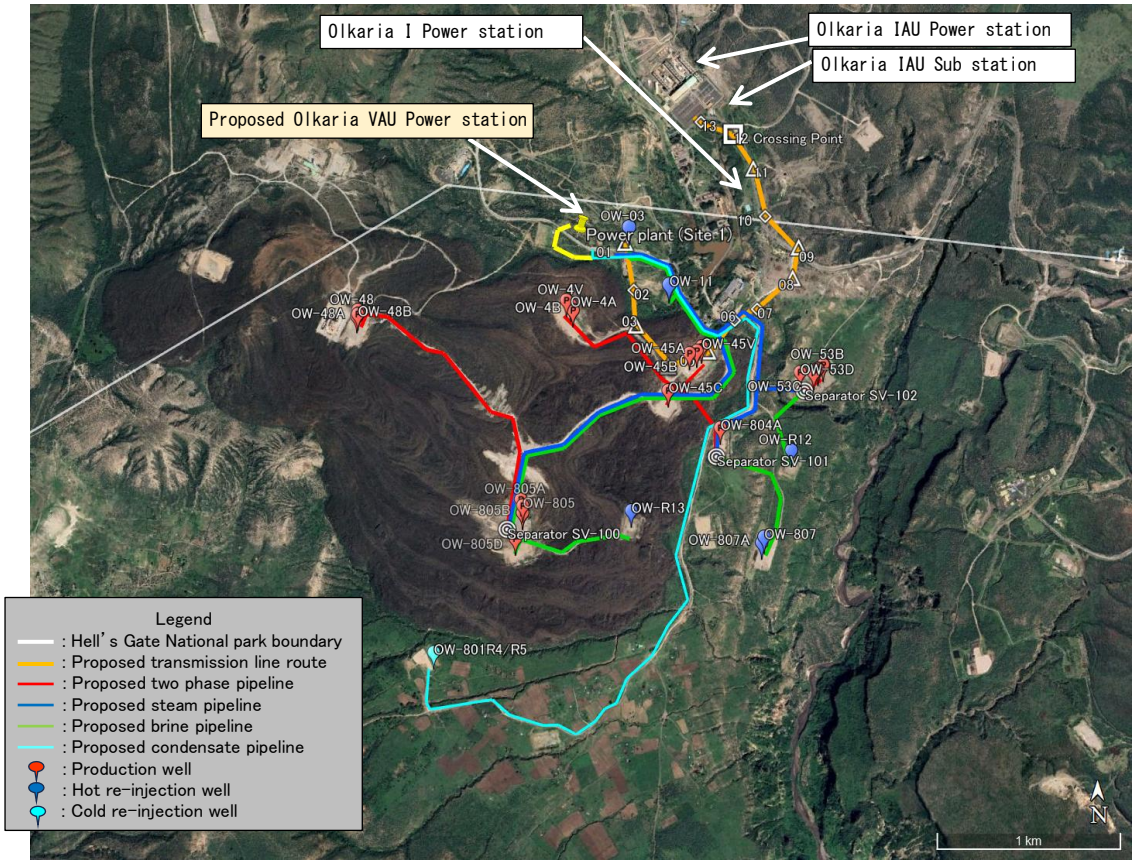


Fig. 1-1. Olkaria VAU Project Site

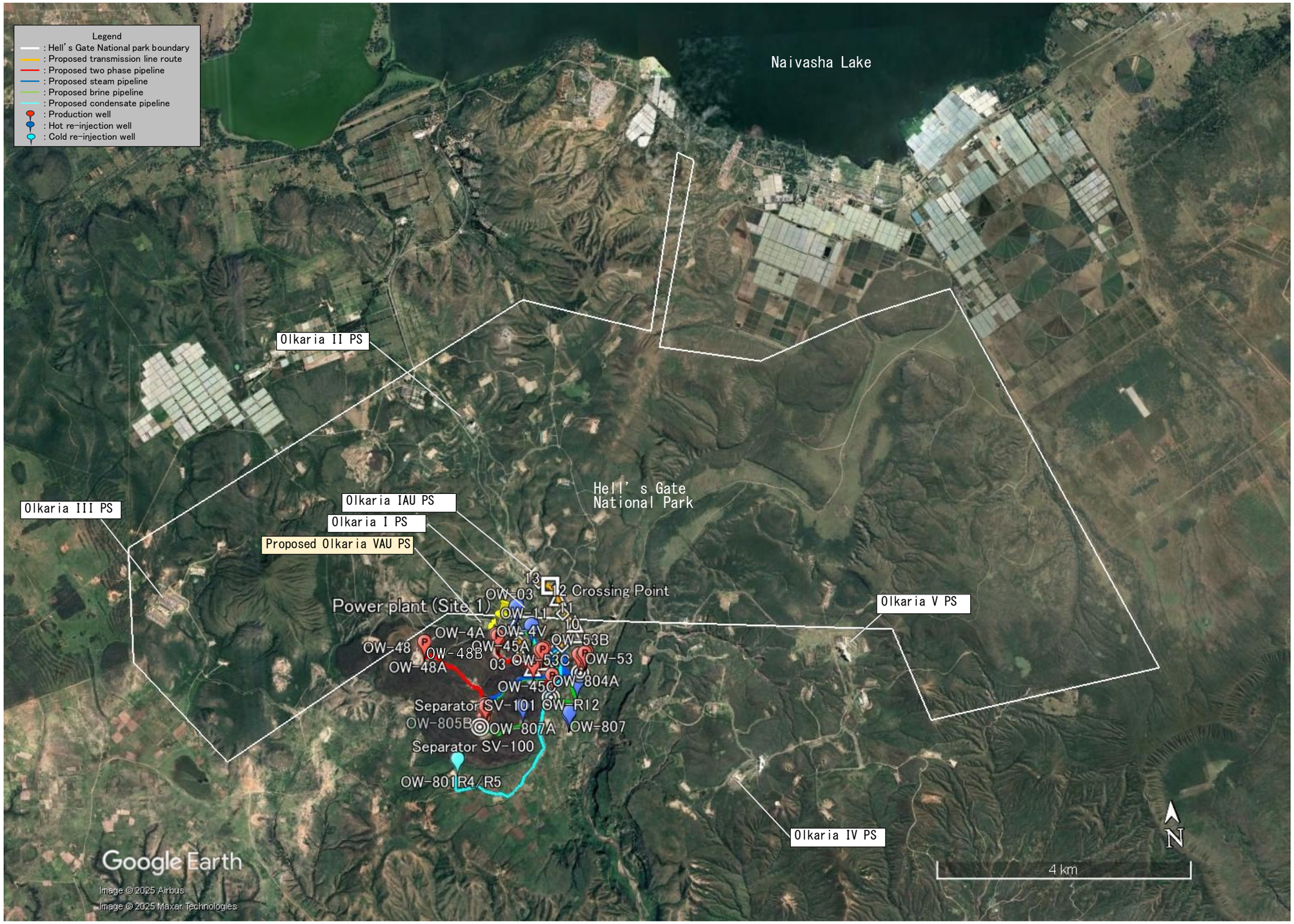


Fig. 1-2. Location Map of the Olkaria VAU Project Site and Existing Power Plants in its Vicinity

Table 1-1. Evaluation results for IFC conditions

Condition	Evaluation result
(1) There are no feasible alternatives to implementing the project in areas other than those specifically designated by the government for natural or cultural heritage protection (hereinafter referred to as "said areas").	The transmission line could be connected to the Olkaria IV Power Plant (outside the park) substation, which is approximately 4 km away across the valley in the southeast direction, as an alternative. Furthermore, the alternative of connecting to a different substation is not feasible for the following reasons: • The 220kV transmission line for this project requires towers approximately 33 meters high, but in the valley, towers around 55 meters high would be needed to maintain clearance between the transmission line and the ground. There are locations in the valley where construction would be difficult due to site conditions. • The valley is a tourist route and a scenically important spot. Since Central Tower is also located there, the construction of transmission lines should be avoided.
(2) Development activities in said areas are permitted under the domestic laws of the host country.	Since KenGen has acquired geothermal resource licenses for the entire project site, there are no legal issues regarding development activities within the national park. KenGen has also signed a MoU (Memorandum of Understanding, 2008) with KWS (Kenya Wildlife Service), which manages Hell's Gate National Park, regarding geothermal development within the park, including environmental consideration measures. KenGen conducts development activities in accordance with this MoU while holding regular committee meetings with KWS.
(3) The project implementation organization, etc., complies with the laws and ordinances of said areas, and the management plan of the protected area.	KenGen has signed a MoU (Memorandum of Understanding, 2008) with KWS (Kenya Wildlife Service), which manages Hell's Gate National Park, regarding geothermal development within the park, including environmental consideration measures, and conducts development activities in accordance with this MoU. In addition, geothermal development is carried out based on the zoning of the national park according to the "Hell's Gate-Mt. Longonot Ecosystem Management Plan, 2010-2015" (KWS), and policies for natural protection and conservation of flora and fauna.

Condition	Evaluation result
(4) The project implementation organization, etc., has consulted with the administrative authority of said areas, the surrounding local communities, and other relevant stakeholders, and has obtained agreement on the implementation of the project.	KenGen conducted twenty-five (25) stakeholder consultations regarding the ESIA of the Olkaria VII project, over a total of fifteen (15) days from April to June 2023, targeting directly affected stakeholders (PAPs) and indirectly affected stakeholders, and obtained agreement regarding the project implementation.

<table>
<tr><th>Condition</th><th>Evaluation result</th></tr>
<tr><td>(5) The project implementation organization, etc., implements additional programs as necessary for said areas to be effectively managed in accordance with their conservation objectives.</td><td>KenGen has also signed a separate MoU with KWS, balancing both geothermal development and environmental conservation within the national park. The main contents of the environmental conservation agreement are as follows:

《Flora》
• KenGen shall not alter natural vegetation in the park except where unavoidable for construction or similar activities, and any alteration shall be minimal.
• KenGen shall cooperate with KWS to eradicate invasive species that have entered due to construction work.
• KenGen shall cooperate with KWS to re-vegetate areas where vegetation has been removed using native species, and shall submit a schedule for this.
• KenGen and KWS shall continuously monitor natural vegetation.

《Fauna》
• Regarding construction work such as pipelines that may affect animal movement, KenGen shall consult with KWS and consider the design. Furthermore, the installation of fences shall be limited to areas deemed necessary for the protection of users.
• Speed bumps shall be installed on roads where animals are expected to cross.
• KenGen and KWS shall not conduct nighttime vehicle movement within the national park, except when necessary for power plant operations or park patrols.

《Soil》
• KenGen shall minimize topographical changes.
• KenGen shall maintain the roads constructed for the power plant.
• KenGen and KWS shall monitor the effectiveness of soil erosion countermeasures. If deemed inadequate, the content shall be reviewed, and information shall be shared between both parties.

《Air》
• KenGen shall continuously conduct meteorological monitoring (including H_2S concentration) and share the data between both parties.

《Noise》
• KenGen shall regularly monitor noise levels.
• Information on noise levels within the park shall be shared, and park visitors shall be informed in advance when significant temporary noise is expected.

Under this MoU, KenGen and KWS are stipulated to hold regular committee meetings at least once every four months. Development activities by KenGen within the park will be discussed with KWS at these committee meetings.</td></tr>
</table>

2 ALTERNATIVE POWER GENERATION SYSTEM

2.1 ALTERNATIVE ANALYSIS

For the location of the power plants and the power generation systems, an alternative analysis was conducted to reduce negative environmental and social impacts, including impacts to land acquisition and resettlement, and the Project cost, as well as to maximize the achievement of the Project. Additionally, regarding the production wells, an alternative plan was considered, assuming that existing wells within the national park would not be used. Alternatives may affect the fluid collection and reinjection system, but there will be no major changes to the steam source selection or power plant design. Therefore, these unaffected factors are excluded from analysis.

As the power transmission lines and geothermal pipelines are realistically set to routes that minimize impact, no alternative analysis will be conducted.

2.2 LOCATION OF THE POWER PLANTS

Based on technical, environmental, and economic considerations, and following discussions on constructability and environmental aspects, the seven candidate sites (Sites 1 to 7) were narrowed down to three: Site 1, Site 6, and Site 7.

Sites 2, 3, 4, and 5 were excluded for the following reasons.

Site 2: Excluded because it's located within the National Park.

Site 3: Excluded due to its proximity to Ole Miyan Village (1.5 km).

Site 4, and 5: Excluded because of its highly uneven terrain on a lava dome, making it difficult to secure the flat land needed for power plant construction.

Site 1, Site 6, and Site 7, for which alternatives were examined, corresponds to Alternatives 1, 2, and 3, respectively, as described later.

Alternatives 1 to 3 involved selecting areas suitable for power plant construction based on aerial photography data and elevation data, followed by on-site verification to determine detailed locations.

Alternative 4 (zero option), while not having negative impacts on the natural and social environment, does not rectify the current vulnerable power supply situation due to tight power supply and demand.

Alternative 1 is located on a gentle slope near the national park and is far from production wells, but it is also far from important habitats of local communities and wildlife, resulting in fewer negative impacts on the social environment.

Alternative 2 is located away from the national park but includes lava fields that symbolize the surrounding

terrain and is a habitat for the Dik-Dik, so the impact on the natural environment is considered greater than Alternative 1. Additionally, it is close to the nearest settlement, raising concerns about impacts on the community.

Alternative 3 is a relay point for existing steam pipes and power transmission lines, but it is close to scenic spots in Hell's Gate National Park such as the Maasai Cultural Center, Central Tower, and Ol Njorowa Gorge, and therefore is considered to have a significant negative impact on the social environment.

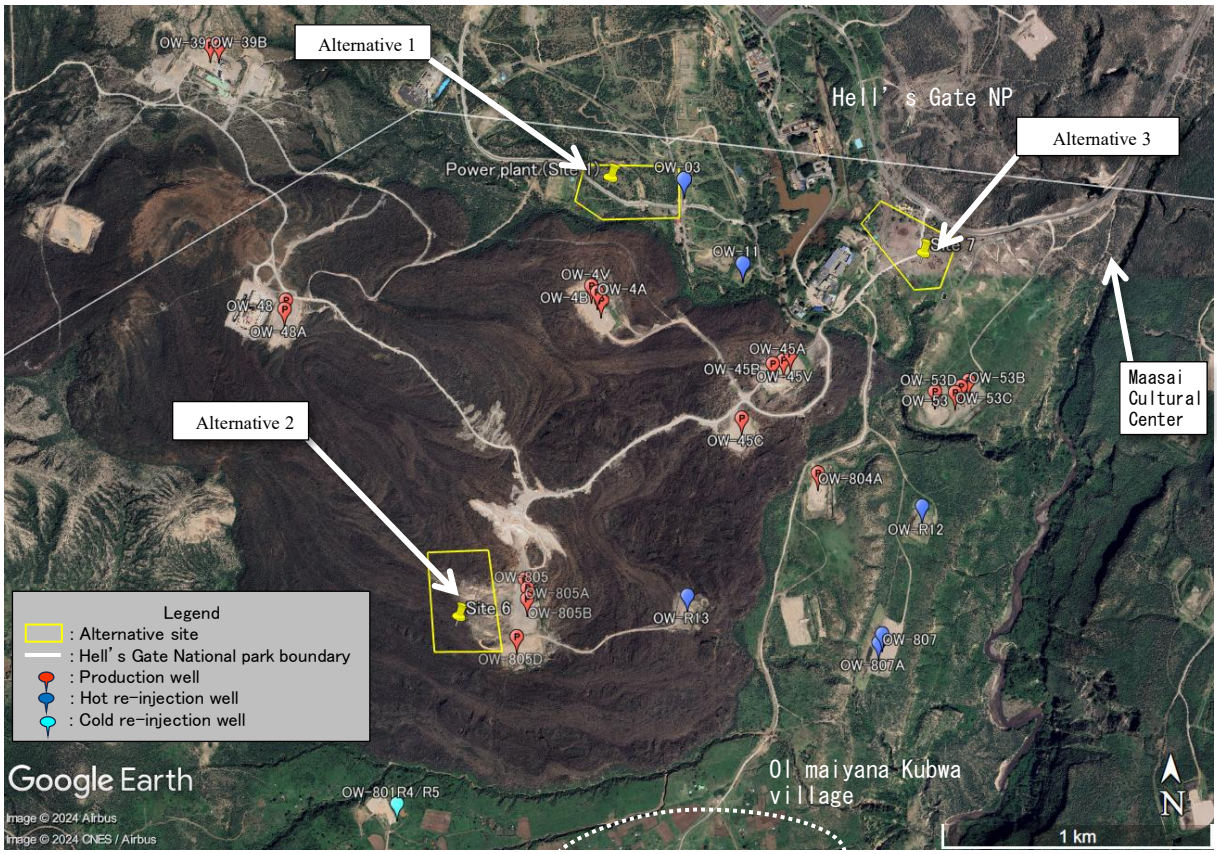
Based on the above, Alternative 1 is the most recommended.

Table 2-1. Alternative Plans Regarding the Location of the Power Plant

Item		Alternative 1	Alternative 2	Alternative 3
Development Effect		Power plant 80.3MW x 1, steam gathering system, transmission lines, etc.	Same as Alternative 1	Same as Alternative 1
(Scoring: 25)		(25)	(25)	(25)
Environmental Aspects		• As the compensatory vegetation consists of bush or grassland used for grazing, the impact on flora and fauna is minimal.	• There is a possibility of destroying the lava flow topography. • It is a habitat for Dik-Dik, and there may be an impact.	• As the compensatory vegetation consists of grassland used for grazing or bush, the impact on flora and fauna is minimal. • It is somewhat close to cliff areas that include important habitats for vultures and other raptors.
(Scoring: 15)		(15)	(10)	(10)
Social Aspects	Land Acquisition	• Since it will be constructed on land owned by KenGen, land acquisition will not be necessary.	• Same as Alternative 1	• Same as Alternative 1
	(Scoring: 10)	(10)	(10)	(10)

Item		Alternative 1	Alternative 2	Alternative 3
Social Aspects	Social Environ-ment	• Although close to Hell's Gate National Park, there are no scenic views in the vicinity and no access roads for tourists, so the impact on the landscape is minimal. • Located approximately 2,000m away from the nearest settlement, resulting in a minimal impact on the community.	• Located away from Hell's Gate National Park, with no tourist scenic views in the vicinity and no access roads for tourists, so there is no impact on the landscape. • Located approximately 800m from the nearest settlement, raising concerns about the impact on the community.	• The impact on the landscape is anticipated due to the proximity to scenic viewpoints within Hell's Gate National Park, such as Central Tower and Ol Njorowa Gorge. • Located approximately 2,000m away from the nearest settlement, resulting in a minimal impact on the community, but located approximately 600m from the Maasai Cultural Center, raising concerns about the impact on tourism.
	(Scoring: 15)	(15)	(10)	(10)
Comparison of Economic Efficiency		• Civil engineering work mainly involves land leveling and drainage work, and the costs are relatively low. • Pipelines cost including removal of existing will be relatively high.	• It is necessary to cut off and flatten a rocky ridge, resulting in large-scale civil engineering work and relatively high costs. • Cost for transmission line will be relatively high.	• Civil engineering work mainly involves drainage work, and the costs are relatively low.
(Scoring: 25)		(24)	(24)	(25)
Technical Aspects		• The availability of flat space is high. • Easiness of access is high. • Proximity to geological fault is high.	• The availability of flat space is low. • Easiness of access is low. • Proximity to geological fault is low.	• The availability of flat space is high. • Easiness of access is high. • Proximity to geological fault is high.
(Scoring: 10)		(10)	(8)	(10)
(Total score: 100)		(99)	(87)	(90)

*The most preferred alternative was given a perfect score, and scoring was conducted based on a relative evaluation against that alternative.



Source：Adapted from Google Earth

Fig 2-1. Project Location Map for Each Alternative Plan



Alternative 1	Alternative 2	Alternative 3

Fig 2-2. Site Conditions for Each Alternative Plan（Photo by JICA's study team in July 2024）

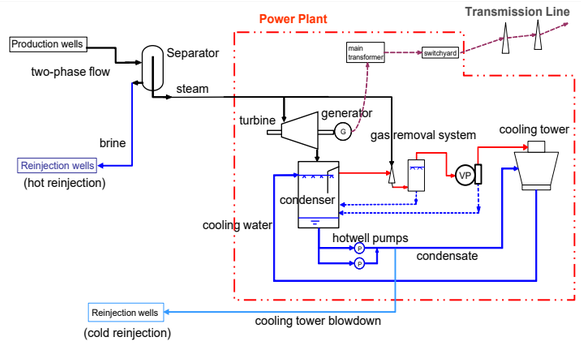
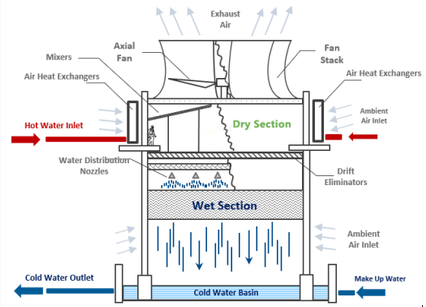
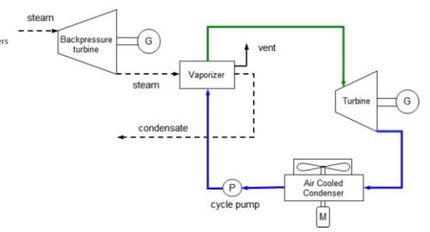
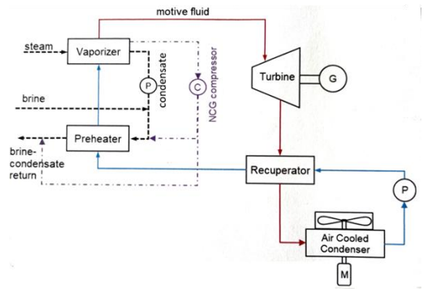
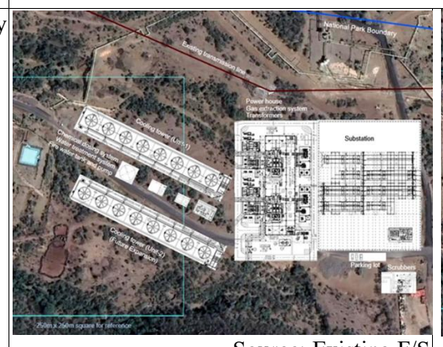
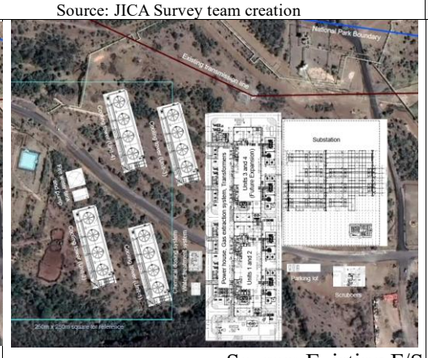
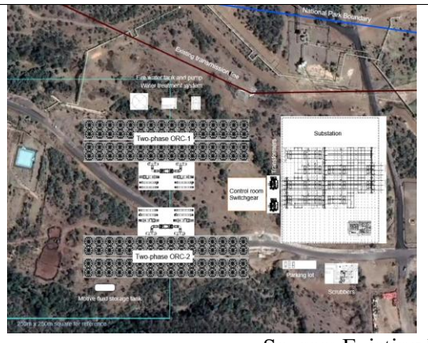
2.3 ALTERNATIVE POWER GENERATION SYSTEMS

Five power generation systems considered suitable for the geothermal resources of this project were compared in Olkaria-VII Geothermal Power Plant Feasibility Study Report (West Japan Engineering Consultants, 2023).

The results of comparing the five power generation systems, including environmental and social aspects, are shown in the table below. In terms of environmental and social aspects, Alternative 5 has high superiority because there is no discharge of H2S. However, since Alternative 5 has a minimal output, the scale of modification relative to the output is larger than Alternatives 1 and 2. If Alternative 5 were to

achieve the same output as Alternatives 1 and 2, a larger-scale construction would be necessary. Therefore, in terms of environmental and social aspects, it is considered that there is no significant difference among Alternatives 1 to 5 that would contribute to changing the power generation system. As a result of comprehensively considering power generation efficiency, economic efficiency, and operational risk, Alternative 1 is considered the most suitable option.

Table 2-2. Comparison of alternatives of power generation systems

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Power generation system	Single-flash cycle condensing steam turbine	Single-flash cycle condensing steam turbine	Single-flash cycle condensing steam turbine	Combination of back pressure steam turbine and binary cycle	Steam/hot-water binary cycle
Number of units	1	2	1	Steam turbine x 1 + Binary x 2	2
Cooling system	Wet cooling tower	Wet cooling tower	Hybrid cooling tower (dry section heat load 10%)	Air cooled condenser	Air cooled condenser
Conceptual diagram	 Source: JICA Survey team creation		 Source: Existing F/S	 Source: Existing F/S	 Source: Existing F/S
Layout plan by existing F/S	 Source: Existing F/S	 Source: Existing F/S	Same as Alternative 1	 Source: Existing F/S	 Source: Existing F/S
Net Output (MW)	76.14	76.14	75.14	56.44	54.41
(Scoring: 30)	(30)	(30)	(30)	(22)	(21)
Geothermal fluid reinjection rate (%)	72.0	72.0	74.7	99.9	99.8
(Scoring: 10)	(7)	(7)	(7)	(10)	(10)
Preliminary CAPEX (million USD/MW)	4.42	4.83	4.96	5.91	5.97
(Scoring: 30)	(30)	(27)	(26)	(20)	(19)
Technical Aspects	・Same system as existing, so there are no operational and maintenance issues ・Low risk of scale	・Same system as existing, so there are no operational and maintenance issues ・Operational flexibility ・Low risk of scale	・Cooling tower plume is inconspicuous ・Slightly increased condensate recovery ・Low risk of scale ・Maintenance of dry heat exchanger in cooling tower is labor-intensive	・No cooling tower plume ・Low risk of scale	・No cooling tower plume ・Compressor required to inject non-condensable gas into hot water for scale control (pH adjustment) ・Hot water pump required
(Scoring: 15)	(14)	(15)	(9)	(12)	(9)

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Environmental and social aspects	・Slightly smaller modification area	・Slightly larger modification area	・Slightly smaller modification area ・Cooling tower may be taller and require a larger installation area	・Slightly smaller modification area ・Minimal output, so the scale of modification relative to the output is large ・Large installation area for air-cooled condenser (no space for future expansion)	・Slightly larger modification area ・Large installation area for air-cooled condenser (no space for future expansion) ・Minimal output, so the scale of modification relative to the output is large ・No H_2S emissions
(Scoring: 15)	(15)	(10)	(12)	(10)	(13)
Evaluation results and ranking	1	2	3	4	5
(Total Score: 100)	(96)	(89)	(84)	(74)	(72)

Source：Olkaria VII F/S, JICA survey team

*The most preferred alternative was given a perfect score, and scoring was conducted based on a relative evaluation against that alternative.

2.4 ALTERNATIVE PLAN FOR PRODUCTION WELLS BASED ON THE KENYAN GOVERNMENT'S POWER DEVELOPMENT PLAN

We've explored alternative plans for the production wells, assuming that the wells within the national park will not be utilized.

Alternative 1: A plan to drill new wells outside the national park to replace OW-39 and OW-39B.
Alternative 2: A plan to reduce output by not using OW-39 and OW-39B.
Alternative 3: A plan to maintain output without using OW-39 and OW-39B.
Alternative 4: A plan to use OW-48B as a substitute well for OW-39 and OW-39B.

Our analysis has led to the following conclusion:
As a result, Alternative Plan 4 is the most recommended. This option ensures a sufficient supply margin and avoids the need to drill additional wells, resulting in the least environmental impact. Furthermore, it aligns with the Kenyan government's power development plan and remains financially viable.

Table 2-3. Comparison of Alternative Plans for Production Wells

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Conditions for each case				
Use of production well(s) outside National Park	Drill additional production wells	None	None	Use one additional existing production well (OW-48B)
(Scoring:10)	(5)	(10)	(10)	(10)
Steam supply initial margin	25%	25%	10.4%	23%
(Scoring:10)	(10)	(10)	(5)	(10)
Expected Results				
Power output	80.3 MW gross	71 MW gross	80.3 MW gross	80.3 MW gross
Cost for additional drilling outside National Park	18 million USD (Note 4)	0	0	0
FIRR (Financial Internal Rate of Return)	1.60%	1.99%	2.68%	2.57%
WACC (Weighted Average Cost of Capital)	3.59%	2.26%	2.29%	2.30%
NPV (Net Present Value)	- USD 56.1 mil.	- USD 7.3 mil.	USD 11.4 mil.	USD 8.2 mil.
LCOE (Levelized Cost of Electricity = Required electricity sales price for project viability)	6.08 cent/kWh	5.35 cent/kWh	5.11 cent/kWh	5.15 cent/kWh
Project Economics	Financially not viable (FIRR < WACC and NPV < 0)	Financially not viable (FIRR < WACC and NPV < 0)	Financially viable (FIRR > WACC and NPV > 0)	Financially viable (FIRR > WACC and NPV > 0)
(Scoring:30)	(5)	(10)	(30)	(30)
Deviation from Kenya's Least Cost Power Development Plan (LCPDP)	None	Approx. 9.3MW deficit	None	None
(Scor:30)	(30)	(10)	(30)	(30)
Risk of future steam production capacity shortage (geothermal specific risk)	High (Risk of reduced steam production per well due to interference between existing wells and additionally drilled wells outside the park, and risk of early production cessation due to stronger decline in geothermal reservoir temperature and pressure.)	Low	High (Risk of earlier drilling of make-up wells and increased number of make-up wells required due to small supply margin.)	Low
(Scoring:20)	(5)	(20)	(10)	(20)
(Total Score:100)	(55)	(60)	(85)	(100)

(1) The electricity selling price of 5.25 US cents/kWh is assumed, as indicated in Kenya's Least Cost Power Development Plan (LCPDP 2024-2043).

(2) Past well drilling costs are treated as sunk costs.

(3) It is assumed that KenGen will bear 100% of the additional drilling costs.

(4) If new wells are to be drilled in different locations instead of the two existing wells within the park, there's a possibility that both new wells might not produce sufficient steam (a risk inherent to geothermal development). Therefore, the drilling three wells should be considered.

3 SCOPING

A scoping of items that are presumed at present to have or not have an impact on the environment is shown in the table below.

Table 3-1. Scoping

Item		Evaluation		Reason
		Construction stage	Operation period	
1. Pollution				
Air pollution	H_2S	—	✓	**Construction stage:** No impact is assumed by the construction of the power plant, the fluid collection and reinjection systems, the transmission line, and a small stretch of the road. **Operation period:** Since NCG containing H_2S will be constantly emitted from the cooling tower of the power plant, there may be an impact on air quality in the neighborhood of the power plant. There may also be cumulative impact, including the H_2S emitted from the existing power plant. No impact is assumed by operation of the fluid collection and reinjection systems, the transmission line, and the small stretch of the road.
	Dust	✓	—	**Construction stage:** Existing paved roads will be used to transport materials to and from the construction sites. This will create dust, and if private homes or other such structures near the transport route may be affected to some degree. **Operation period:** There will be little or no particular impact in terms of dust, as vehicular traffic will be quite limited.

Item	Evaluation		Reason
	Construction stage	Operation period	
Water contamination	—	—	**Construction stage:** During construction, no wastewater will be generated. Even if unforeseen wastewater is produced and flows out, as the volume will be insignificant, they will disappear via evaporation, etc. before they reach any rivers or lakes. There are no rivers in the project area. Impact is thus unlikely. **Operation period: A**s reinjection wells and production wells will have steel casing pipes (water shielding pipes) inserted deep underground below an impervious stratum, gaps between well walls and pipes will be filled with cement, and collection and reinjection of geothermal fluid will be conducted deep underground, impact on water contamination is unlikely.
Waste	✓	✓	**Construction stage:** Industrial waste is likely to be generated by construction of the power plant, the fluid collection and reinjection system, transmission lines, and small roads. **Operation period:** Industrial waste (sludge generated from cleaning of the cooling tower pit during inspection, and waste oil from turbines, etc.) is likely to be generated during the maintenance of the power plant, the small road.

Item	Evaluation		Reason
	Construction stage	Operation period	
Noise and vibration	✓	✓	**Construction stage:** Noise and vibration created by the operation of construction machinery used for construction of the power station, the fluid collection and reinjection systems, the transmission line, and the small stretch of the road, are likely to have some impact on the environment. In addition, the traffic of vehicles transporting materials to and from the construction sites may also have some impact if there are private homes or other such structures along the transport route. **Operation period:** Noise and vibration generated by the cooling towers, steam turbines, generators and other power plant equipment are likely to have some impact on the neighboring area. The planned project site is roughly 1.8 km from the nearest existing power plant, so a cumulative impact is unlikely. As noise and vibration from the fluid collection and reinjection system, the transmission lines and the small stretch of the road will be extremely minor, no impact is expected.

Item	Evaluation		Reason
	Construction stage	Operation period	
Ground subsidence	—	—	**Construction stage:** No impact that could cause ground subsidence is likely during the study phase, because the emission of geothermal fluids is very brief. Construction of the power plant, the fluid collection and reinjection system, the transmission lines, and the small stretch of the road is not expected to have any impact that could cause ground subsidence, either. **Operation period:** Although geothermal fluids will be extracted from deep underground, the entire volume will be reinjected. According to KenGen, ground subsidence has not occurred at the existing power plants and no reports or complaints regarding ground subsidence have been received. Therefore, impact is unlikely. The power plant, the fluid collection and reinjection system, the transmission lines and the small road operation are not expected to have any impact.
Offensive odors	—	✓	**Construction stage:** Construction of the power plant, the fluid collection and reinjection system, the transmission lines, and the road is not expected to have any impact. **Operation period:** The offensive odor of H_2S released from the cooling towers may have some impact on the neighborhood of the power plant. There may also be cumulative impact, including the H_2S emitted from the existing power plant. The fluid collection and reinjection system, transmission lines and the small stretch of the road operation are not expected to have any impact.

Item	Evaluation		Reason
	Construction stage	Operation period	
2. Natural Environment			
Protected area (National Park)	✓	✓	**Construction stage:** Since the power plant construction will take place outside the national park, no direct modification of the national park will occur; however, temporary noise impacts are anticipated. The construction of the power transmission line and the paving of the access road within the national park will follow the existing road. Consequently, this will impact a portion of the national park. **Operation period:** Impact from H_2S, noise, etc. from the power plants (including existing ones) is likely. The presence of the power plant, the transmission lines and the small stretch of the road may have some impact on the animals and landscape.
Fauna, flora, and biological diversity	✓	✓	**Construction stage:** Grasslands and bush are distributed throughout the project site, where felling of trees and land alterations for construction of the power plant, the fluid collection and reinjection system, transmission lines and small stretch of the roads may have some impact. The carrying in of materials and the passage of construction vehicles may lead to the introduction and proliferation of invasive plant species. **Operation period:** The presence of the existing and new power plants, the fluid collection and reinjection systems, transmission lines and small roads may affect the distribution of animals and plants, as well as their breeding and living environments. The passage of construction vehicles may lead to the introduction and proliferation of invasive plant species. There are no structures near the cliff where the colonies of Ruppell's vultures and Egyptian vultures are located.

Item	Evaluation		Reason
	Construction stage	Operation period	
Hydrology	—	—	**Construction stage:** Intake of cooling water for power plant construction will be only temporary and in minimal amounts, and no large-scale water intake from Lake Naivasha will take place. Thus, there will be no impact. Even if a need for water intake arises for use in the construction of the fluid collection and reinjection system, the transmission lines, and the small stretch of the road, the required amount will be minimal, and there will be no impact on hydrology. **Operation period:** Non-operational water will be drawn from Lake Naivasha. As the volume is minimal, there will be no impact.
Groundwater	—	—	**Construction stage:** No intake of groundwater for construction work is planned. Thus, impact on groundwater is unlikely. **Operation period:** No intake of groundwater for use in the power plant is expected. In addition, as reinjection wells and production wells will have steel casing pipes (water shielding pipes) inserted deep underground below an impervious stratum, gaps between well walls and pipes will be filled with cement, and collection and reinjection of geothermal fluid will be conducted deep underground, impact on groundwater is unlikely. The power plant, the fluid collection and reinjection system, the transmission lines and the minimal road operation will have no impact on the groundwater.

Item	Evaluation		Reason
	Construction stage	Operation period	
Soil erosion	✓	✓	**Construction stage:** Construction of the power plant, the fluid collection and reinjection system, geothermal wells, transmission lines and small roads will produce exposed ground, and rainfall may cause this exposed ground to erode. No impact on the small stretch of the road is assumed because of paving the road. **Operation period:** Soil erosion by rainfall is likely to occur if exposed ground remains bare for a prolonged period.
Topographical and geological features	—	—	**Construction stage:** Construction of the power plant, the fluid collection and reinjection system, the transmission line and the small stretch of the road will involve some topographical alteration of the land. However, no impact is likely as there are no significant topographical or geological features needing to be preserved in the area. **Operation period:** No impact is likely as there will be no construction that will cause alteration to topographical or geological features.

Item	Evaluation		Reason
	Construction stage	Operation period	
Global warming/ climatic variation	—	✓	**Construction stage:** Greenhouse gases generated by the construction of the power plant, the fluid collection and reinjection system, the transmission line, and the small stretch of the road will be minimal, and the impact of these emissions is expected to be temporary and minor. The construction site is in bush or grassland, and no felling of trees in forests will be needed. Therefore, the removal of plants will barely have any impact on greenhouse gas levels. **Operation period:** CO_2 and other components of non-condensable gas (NCG) will be released from the cooling tower. Compared with other steam power generation methods, greenhouse gas emissions from geothermal power generation are considerably minimal, which should contribute to reductions in CO_2 emissions in Kenya. There will be no direct release of CO_2 from the fluid collection and reinjection system, the transmission lines or the small stretch of the road.
3. Social Environment			
Land acquisition and resettlement	—	—	**Construction stage / Operation period:** There are no residences on the project site, and the project is planned on land owned by KenGen that is not in use, therefore no land acquisition or relocation of residents is expected.
Living and livelihood	✓	✓	**Construction stage / Operation period:** Some reduction of grazing land is expected but alternation of living and livelihood is not expected. Also, employment opportunities seem to increase during construction and operation phase.
Heritage	—	—	**Construction stage / Operation period:** No heritage or cultural assets are expected in the Project site.

Item	Evaluation		Reason
	Construction stage	Operation period	
Landscape	✓	✓	**Construction stage:** The Project may have impact on landscape from observation deck in the National Park, which is neighboring the Project site. Also impacts by the pipeline and the power transmission line to the landscape are expected. **Operation period:** Change of the scenic view from viewpoint is expected by the presence of power plant facilities.
Ethnic minorities and indigenous peoples	—	—	**Construction stage / Operation period:** The project is located on KenGen's property and there is no human habitation or use by surrounding residents in the proposed project area; therefore, no impacts are anticipated.
Poverty groups	—	—	**Construction stage / Operation period:** Inhabitation status of poverty groups in the Project site is unknown.
Land use / Natural resource / Hot springs	✓	✓	**Construction stage:** Acquisition and alternation of some grazing land owned by a private company are required by Project construction. In other parts of the Project site, alteration of land use is not expected. **Operation period:** alternation of land use is not expected during operation phase. **Construction stage / Operation period:** In volcanic geothermal areas, if hot spring facilities exist, impacts are expected.

Item	Evaluation		Reason
	Construction stage	Operation period	
Water Use	—	—	**Construction stage:** Although water use from Lake Naivasha is planned, the water intake during construction will be temporary and the amount of water used for construction of the power plant will be minimal, therefore no impact on water usage from Lake Naivasha is expected. **Operation period:** Although water use from Lake Naivasha is planned, the project's characteristics and scale mean that this will not involve large-scale water intake, therefore no impact on water usage from Lake Naivasha is expected.
Existing social Infrastructures and social services	—	—	**Construction stage / Operation period:** Construction and operation activities are expected to have no impact on social infrastructures and social services.
Social institutions and local decision-making institutions	—	—	**Construction stage / Operation period:** Geothermal power plants have been operated since 1981 in the area, and also construction of other power plants was conducted in the area. Thus, a significant impact to the local society by the Project is not expected.
Misdistribution with unfair distribution of benefits and damages	✓	—	**Construction stage:** When the Project employs local laborers, there might be misdistribution with unfair distribution of benefits and damages. To avoid the misdistribution, appropriate measures will be considered. **Operation period:** Since the project provides power supply as public service, no misdistribution with unfair distribution of benefits and damages is expected.

Item	Evaluation		Reason
	Construction stage	Operation period	
Gender	—	—	**Construction stage / Operation period:** Since there are no settlements within the project site, gender impacts are not anticipated. Furthermore, while local women sell handicrafts and other items at the Maasai Cultural Center, it is located 1.6 km away from the project site, and construction vehicles will not use the access route to the Maasai Cultural Center; therefore, no gender impacts are anticipated.
Children's rights	—	—	**Construction stage / Operation period:** No impact is expected because the project will not block access to schools or school routes.
Local conflicts of interest	—	—	**Construction stage / Operation period:** Since the project provides power supply as public service, no Local conflicts of interest are expected during operation phase. However, in the construction phase, appropriate measures should be considered during compensation payment.
Health / Public health	✓	—	**Construction stage:** The lack of sanitary facilities, insufficient sanitary facilities, and minimal treatment capacity may lead to the deterioration of public health. **Operation period:** Almost no impact is expected, because sanitary facilities will be installed and maintained.
Infectious disease such as HIV/AIDS	✓	✓	**Construction stage:** If many external construction workers are involved in the construction of power generation facilities, risk of infection and spread of HIV/AIDS is expected. **Operation period:** If there are many workers involved in the operation of power generation facilities, risk of infection and spread of HIV/AIDS is expected.

Item	Evaluation		Reason
	Construction stage	Operation period	
Working environment	✓	✓	**Construction stage / Operation period:** Accidents during construction and risk of disease occurrence are expected to increase, if the hard and the soft aspects (shown below) are insufficient. The hard aspects: the compliance with laws, regulations regarding working environments, the installation of safety equipment to prevent occupational accidents, etc. The soft aspects: the establishment of safety, health plans and safety education for workers, etc.
4. Others			
Accidents	✓	✓	**Construction stage:** With insufficient safety management, ejection of geothermal fluid during survey, accident during construction and traffic accident may increase. **Operation period:** With insufficient safety management, leakage of high-concentration H_2S gas, blowout high temperature steam and shatter of hot water can be expected.

* ✓: Impact is likely, or the degree of impact is unidentified, and future investigation for clarification is needed.

－: As the impact will be minimal, future investigation is unnecessary.

4 ENVIRONMENTAL ASSESSMENT MATRIX

Based on the results of the environmental and social consideration survey, the Team evaluated the potential impact of the Project as shown below.

Table 4-1. Evaluation of Potential Impact

Item		Provisional Scoping of Impact		Scoping after the survey and the review		Reason
		Construction stage	Operation period	Construction stage	Operation period	
1.Pollution						
Air pollution	H_2S	—	✓	N/A	0	**Construction stage:** No impact is assumed by the construction of the power plant, the fluid collection and reinjection systems, the transmission line, and a small stretch of the road. **Operation period:** During operation, H2S is the main air emission from cooling towers. Simulations using AERMOD software indicate that even at sensitive receptors, H2S concentrations remain below Kenyan and international air quality standards.
	Dust	✓	—	-1	N/A	**Construction stage:** Increase in dust pollution will mainly emanate from road pavement activities and operations in quarries and borrow pits in the project area. **Operation period:** There will be little or no particular impact in terms of dust, as vehicular traffic will be quite limited.

Item	Provisional Scoping of Impact		Scoping after the survey and the review		Reason
	Construction stage	Operation period	Construction stage	Operation period	
Water contamination	—	—	N/A	N/A	**Construction stage:** Only storm water will be drained into gullies via natural process. Additionally, the wastewater will be stored and then collected by a licensed wastewater treatment company in Kenya. **Operation period:** Only storm water will be drained into gullies via natural process. Additionally, the wastewater will be stored and then collected by a licensed wastewater treatment company in Kenya. In addition, as reinjection wells and production wells will have steel casing pipes (water shielding pipes) inserted deep underground below an impervious stratum, gaps between well walls and pipes will be filled with cement, and collection and reinjection of geothermal fluid will be conducted deep underground, impact on water contamination is unlikely.
Waste	✓	✓	-1	-1	**Construction stage / Operation period:** Solid and liquid waste streams will be generated from activities associated with the project construction and operation phases especially from labour campsites and staff houses. Industrial waste, such as construction materials, concrete, paper, wood, scrap metal, plastic, soil from well drilling, excavated spoil (debris, etc.) is likely to be generated.
Noise and vibration	✓	✓	-1	0	**Construction stage:** Increase in noise levels will mainly occur during the use of heavy machinery along the roads and in borrow pits. **Operation period:** It is planned to pave the unpaved access road, and since there are no houses along the main transportation route, no impact is expected.

Item	Provisional Scoping of Impact		Scoping after the survey and the review		Reason
	Construction stage	Operation period	Construction stage	Operation period	
Ground subsidence	—	—	N/A	N/A	**Construction stage:** No impact that could cause ground subsidence is likely during the study phase, because the emission of geothermal fluids is very brief. Construction of the power plant, the fluid collection and reinjection system, the transmission lines, and the small stretch of the road is not expected to have any impact that could cause ground subsidence, either. **Operation period:** Although geothermal fluids will be extracted from deep underground, the entire volume will be reinjected. According to KenGen, ground subsidence has not occurred at the existing power plants and no reports or complaints regarding ground subsidence have been received. Therefore, impact is unlikely. The power plant, the fluid collection and reinjection system, the transmission lines and the small road operation are not expected to have any impact.
Offensive odors	—	✓	N/A	0	**Construction stage:** Construction of the power plant, the fluid collection and reinjection system, the transmission lines, and the road is not expected to have any impact. **Operation period:** Yearly means H_2S concentration levels during the operation period of power plants, including existing plants in the nearest residential area of Ol Mayalna Kubwa Community, are 0.3 $\mu g/m^3$ which is below the threshold of the human sense of smell (0.615 $\mu g/m^3$ [1)]). Therefore, there will barely be any impact caused by offensive odors. 1) Source; "Measurement of threshold value by tiriangle odor bag method （Yoshio Nagata, Bull. Jap. Env. Sanit. Cent. No. 17. 1990）"

Item	Provisional Scoping of Impact		Scoping after the survey and the review		Reason
	Construction stage	Operation period	Construction stage	Operation period	
2.Natural Environment					
Protected area (National Park)	✓	✓	-1	-1	**Construction stage:** Since the power plant construction will take place outside the national park, there will be no direct modification to the national park, but temporary noise impacts are expected. Although the transmission lines and access road paving work are planned to be partially carried out within the national park, the construction work within the national park is planned to be carried out along existing roads, so the impact will be minimal. **Operation period:** The impact of H_2S, noise, etc., from the power plant is expected to be minimal. Transmission lines are planned to be installed along existing roads, and since the vegetation that may be cut down is secondary vegetation bush, the impact is considered minimal. Paving the existing access road is expected to have a positive impact on the environment (e.g. dust, soil erosion) and society.

Fauna, flora, and biological diversity	✓	✓	-2	-2	**Construction stage / Operation period:** Destruction of floral communities will mainly occur in the areas cleared to give way to the power plant, transmission line and substation, installation of steam pipelines and water supply system. Negative impacts on terrestrial fauna occur in the areas cleared to give way to the power plant, transmission line and substation, installation of steam pipelines and water supply system. The carrying in of materials and the passage of construction vehicles may lead to the introduction and proliferation of invasive plant species. There are no structures near the cliff where the colonies of Ruppell's vultures and Egyptian vultures are located. Birds may collide with or be electrocuted by transmission lines. **Supplement)** The project site and its surroundings are already developed areas with existing power plant-related facilities such as geothermal pipelines and transmission towers. Since the same type of environment is widely distributed in the surrounding areas. Regarding the fauna at the project site and its surrounding areas, we have interviewed experts from KWS who are familiar with the wildlife in Hell's Gate National Park and its surrounding areas, and have confirmed that there are no main migration routes, important habitats, such as breeding or wintering sites, for any species, including those on the Red List. Individual interviews with KWS were not conducted for all species listed in the IUCN Red List. However, regarding the hearing with KWS on the impact of this project on wild animals in and around the project site, the only mention was of the potential impact on the movement of wild animals such as giraffes. It was stated that if the geothermal pipeline equipment was installed without consideration for the movement of animals, there could be an impact. KenGen has consulted with KWS when installing geothermal pipelines, and in areas that impede the movement of animals, they have made the geothermal pipelines go underground or curve. The geothermal pipelines for this project will be constructed in consultation with KWS, based on information of the giraffe migration routes and areas where they are often seen.

Item	Provisional Scoping of Impact		Scoping after the survey and the review		Reason
	Construction stage	Operation period	Construction stage	Operation period	
Hydrology	—	—	N/A	N/A	**Construction stage:** Intake of cooling water for power plant construction will be only temporary and in minimal amounts, and no large-scale water intake from Lake Naivasha will take place. Thus, there will be no impact. Even if a need for water intake arises for use in the construction of the fluid collection and reinjection system, the transmission lines, and the small stretch of the road, the required amount will be minimal, and there will be no impact on hydrology. **Operation period:** Non-operational water will be drawn from Lake Naivasha. As the volume is minimal, there will be no impact.
Groundwater	—	—	N/A	N/A	**Construction stage:** No intake of groundwater for construction work is planned. Thus, impact on groundwater is unlikely. **Operation period:** No intake of groundwater for use in the power plant is expected. In addition, as reinjection wells and production wells will have steel casing pipes (water shielding pipes) inserted deep underground below an impervious stratum, gaps between well walls and pipes will be filled with cement, and collection and reinjection of geothermal fluid will be conducted deep underground, impact on groundwater is unlikely. The power plant, the fluid collection and reinjection system, the transmission lines and the minimal road operation will have no impact on the groundwater.
Soil erosion	✓	✓	-1	0	**Construction stage** / **Operation period:** Soil erosion will occur along the exposed road surface and other areas due to the effect of the runoff.

Item	Provisional Scoping of Impact		Scoping after the survey and the review		Reason
	Construction stage	Operation period	Construction stage	Operation period	
Topographical and geological features	—	—	N/A	N/A	**Construction stage:** Construction of the power plant, the fluid collection and reinjection system, the transmission line and the small stretch of the road will involve some topographical alteration of the land. However, no impact is likely as there are no significant topographical or geological features needing to be preserved in the area. **Operation period:** No impact is likely as there will be no construction that will cause alteration to topographical or geological features.
Global warming/ climatic variation	—	✓	N/A	+3	**Construction stage:** Greenhouse gases generated by the construction of the power plant, the fluid collection and reinjection system, the transmission line, and the small stretch of the road will be minimal, and the impact of these emissions is expected to be temporary and minor. The construction site is in bush or grassland, and no felling of trees in forests will be needed. Therefore, the removal of plants will barely have any impact on greenhouse gas levels. **Operation period:** The proposed project has the potential to generate immense carbon credit value for the project proponent.
3.Social Environment					
Land acquisition and resettlement	—	—	N/A	N/A	**Construction stage / Operation period:** The Olkaria VII geothermal power project will be constructed on KenGen-owned land near the southern boundary of Hell's Gate, specifically at the selected Site No. 1. This location ensures no new land acquisition is required, and as there are no residing communities in the project or surrounding areas, no displacement, relocation, or involuntary resettlement of people will occur.

Item	Provisional Scoping of Impact		Scoping after the survey and the review		Reason
	Construction stage	Operation period	Construction stage	Operation period	
Living and livelihood	✓	✓	+3	+3	**Construction stage / Operation period:** This project will contribute to rural electrification, stimulate economic growth in Kenya and boost the growth of local and national economy. The local community will benefit from job opportunities for the semi-skilled and unskilled cadres who will form the bulk of the labour force.
Heritage	—	—	N/A	N/A	**Construction stage / Operation period:** No heritage or cultural assets are expected in the Project site.
Landscape	✓	✓	-1	-1	**Construction stage / Operation period:** Visual intrusion will be prominent during construction phase when project activities will result in deep cuts and accumulation of spoils in several sites of the project area.
Ethnic minorities and indigenous peoples	—	—	N/A	N/A	**Construction stage / Operation period:** The Maasai community is categorized as Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities under the World Bank's ESS7, which aims to protect their human rights, culture, and livelihoods from adverse project impacts. An Indigenous Peoples Plan (IPP) is typically required if such communities are present or attached to a project area. However, the proposed Olkaria VII geothermal power plant project is located on KenGen land with no human settlements, therefore an IPP will not be necessary.
Poverty groups	—	—	+2	+2	**Construction stage / Operation period:** The local community will benefit from job opportunities for the semi-skilled and unskilled cadres who will form the bulk of the labour force.

Item	Provisional Scoping of Impact		Scoping after the survey and the review		Reason
	Construction stage	Operation period	Construction stage	Operation period	
Land use / Natural resource / Hot spring	✓	✓	0	0	**Construction stage:** Acquisition and alternation of some grazing land owned by a private company are required by Project construction. In other parts of the Project site, alteration of land use is not expected. **Operation period:** alternation of land use is not expected during operation phase. **Construction stage / Operation period:** The hot spring facility in this area is a heated pool constructed and managed by KenGen, located more than 3 km away from the project site. The hot water is supplied by diverting a portion of the high-temperature hot water that is injected underground, and since there is an abundant supply of hot water for underground reinjection, the project is not expected to have any impact.
Water Use	—	—	N/A	N/A	**Construction stage:** Although water use from Lake Naivasha is planned, the water intake during construction will be temporary and the amount of water used for construction of the power plant will be minimal, therefore no impact on water usage from Lake Naivasha is expected. **Operation period:** Although water use from Lake Naivasha is planned, the project's characteristics and scale mean that this will not involve large-scale water intake, therefore no impact on water usage from Lake Naivasha is expected.
Existing social Infrastructures and social services	—	—	N/A	N/A	**Construction stage / Operation period:** Construction and operational activities are expected to have no impact on social infrastructures and social services.
Social institutions and local decision making institutions	—	—	N/A	N/A	**Construction stage / Operation period:** Geothermal power plants have been operated since 1981 in the area, and also construction of other power plants was conducted in the area. Thus, a significant impact to the local society by the Project is not expected.

Item	Provisional Scoping of Impact		Scoping after the survey and the review		Reason
	Construction stage	Operation period	Construction stage	Operation period	
Misdistribution with unfair distribution of benefits and damages	✓	—	-1	N/A	**Construction stage:** During the construction of the power plant, etc., the Employment Subcommittee is scheduled to share information and discuss employment opportunities for local residents, so there is little possibility of an uneven distribution of harm and benefits. **Operation period:** Since the project provides power supply as public service, no misdistribution with unfair distribution of benefits and damages is expected.
Gender	—	—	N/A	N/A	**Construction stage / Operation period:** Since there are no settlements within the project site, gender impacts are not anticipated. Furthermore, while local women sell handicrafts and other items at the Maasai Cultural Center, it is located 1.6 km away from the project site, and construction vehicles will not use the access route to the Maasai Cultural Center; therefore, no gender impacts are anticipated.
Children's rights	—	—	N/A	N/A	**Construction stage / Operation period:** No impact is expected because the project will not block access to schools or school routes.
Local conflicts of interest	—	—	N/A	N/A	**Construction stage / Operation period:** Since the project provides power supply as public service, no Local conflicts of interest are expected during operation phase. However, in the construction phase, appropriate measures should be considered during compensation payment.
Health / Public health	✓	—	-1	N/A	**Construction stage:** Increased involvement in the project's activities is likely to lead to increased occupational and health hazards. **Operation period:** Almost no impact is expected, because sanitary facilities will be installed and maintained.
Infectious disease such as HIV/AIDS	✓	—	-1	-1	**Construction stage / Operation period:** Influx of workforce in the project area is likely to lead to increased incidences of HIV/AIDS and other sexually transmitted diseases.

Item	Provisional Scoping of Impact		Scoping after the survey and the review		Reason
	Construction stage	Operation period	Construction stage	Operation period	
Working environment	✓	✓	-1	-1	**Construction stage / Operation period:** The labour force is likely to indulge in harvesting of trees and charcoal making activities to the detriment of the environment of the project area.
4.Others					
Accidents	✓	✓	-1	-1	**Construction stage / Operation period:** Over-speeding on the rehabilitated roads and increased project activities may lead to increase in accidents in the project area.

* 3: Significant impact is likely.
2: Some degree of impact is likely
1: The degree of impact is unidentified, and future investigation for clarification is needed.
0: As the impact will be minimal, future investigation is unnecessary.
+: Positive impact -: Negative impact
N/A: Impact assessment is not conducted because the item was categorized as no effect in scoping phase.

5 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

The mitigation measures set out in Table 5-1 should be implemented to reduce the potential negative impacts of the project. Additionally, measures that have been proven effective in previous projects will also be applied during the construction of this project.

The following measures have proven effective in previous projects:

- Establishing watering holes for wildlife, which helps reduce ecosystem impacts by providing animals with safe access to water.
- Designing pipelines to facilitate animal passage by routing them underground or curving them to avoid obstructing migration routes.
- Preventing soil erosion and carrying out planting to restore vegetation lost to construction activities..
- Painting pipelines with colors and patterns that blend with local vegetation to minimize their visual impact on the landscape.

Table 5-1. Mitigation measures and cost (Construction stage)

Parameters		Impact	Mitigation measures	Responsibility		Estimated Cost (KES)
				Implementing Organization	Supervising Organization	
1	Air pollution	Dust	• Limit levels of dust through good practice such as watering of access routes, construction sites, deviations and other disturbed sites and cover lorries transporting construction materials. • Provide workers with appropriate dust protective gear including masks and overalls.	Contractor	KenGen	4,450,000
2	Water Quality	Impact on soil and waterbodies	• Regularly confirm that septic tanks are functioning properly and undamaged. • Monitor the quality of wastewater discharged from worker campsite.	Contractor	KenGen	2,500,000
3	Waste	Impact on land, water bodies and the environment	• Use suitable human waste disposal systems solar and pit latrines as found appropriate. • Segregate solid wastes in the RE, Contractor and labour camp units and arrange for subsequent disposal through either efficient incineration or disposal in an approved dump or in a sanitary landfill.	Contractor	KenGen	7,000,000
4	Noise and Vibration	Increased noise levels	• Use of protective hearing devices such as ear plugs and earmuffs among project workers when noise levels exceed 85-90 dBA. • Selection of appropriate machinery and regular service of machinery and vehicles. • Monitor noise levels at the usual activity site of workers.	Contractor	KenGen	9,735,000

Table 5-1. Mitigation measures and cost (Construction stage)

Parameters		Impact	Mitigation measures	Responsibility		Estimated Cost (KES)
				Implementing Organization	Supervising Organization	
2.Natural Environment						
5	Protected area (National Park) / Fauna, flora, and biological diversity	Habitat and biodiversity loss	• Discourage any wanton destruction of vegetation and habitats beyond the designed project works. • Restore lost biodiversity on the disturbed area through planting of appropriate trees, shrubs and grasses and protection of fauna species and their habitat. • Identification and mapping of invasive species, primarily through uprooting before flowering. • Participation in monitoring and biodiversity investigations with other stakeholders including KWS and KMFRI. • Increase surveillance and security in the Hell's Gate National Park during the construction stage. Support for local initiatives in environmental protection. • Consider implementing the installation of wire markers on the transmission lines and ensuring sufficient spacing between them to prevent bird electrocution as needed.	Contractor	KenGen	27,429,000
6	Soil erosion	Increased soil erosion and siltation	• Where applicable, install silt traps to reduce sediment load directly entering riverine environments. Carry out terracing and landscaping of the disturbed sites as appropriate. Plant sediment binding grasses, shrubs and trees on the exposed slopes and other surfaces as appropriate.	Contractor	KenGen	13,274,000
3.Social Environment						
7	Landscape	Loss of Landscape	• Rehabilitate all degraded areas through landscaping and subsequent planting of suitable grass, shrubs and trees to blend with the environment. • Paint the power plant and other project buildings and the steam pipelines with appropriate colours.	Contractor / KenGen	KenGen	9,000,000
8	Misdistributio n with unfair distribution of benefits and damages	Worsening of local relationships	• The Employment Subcommittee will share information and discuss employment opportunities for local residents.	Employment subcommittee	KenGen	No additional cost

Table 5-1. Mitigation measures and cost (Construction stage)

Parameters		Impact	Mitigation measures	Responsibility		Estimated Cost (KES)
				Implementing Organization	Supervising Organization	
9	Cultural contamination	Loss of traditional culture	• Conduct awareness training for project workers on local customs and cultural practices. • Educate workers and local residents about STI (sexually transmitted infections) and HIV/AIDS. • Contractors shall inform workers about local culture and STI risks. • Develop an HIV and Culture Prevention Program in accordance with KenGen's HIV/AIDS and EHS policies and include it in the bid documents. • Contractors shall develop and implement an HIV and Culture Prevention Program in accordance with KenGen's program.	Contractor / KenGen	KenGen	No additional cost
10	Gender and Child Labor	Violations of the rights of women and children	• Provide workers with training to prevent issues such as gender discrimination and child labor.	Contractor / KenGen	KenGen	No additional cost
11	Health / Public health	Deterioration of sanitary conditions	• Temporary toilets will be installed and sewage will be treated under the management of the contractor during power plant construction.	Contractor	KenGen	Included in the cost
12	Infectious diseases such as HIV/AIDS	Increase in the prevalence of communicable diseases such as HIV/AIDS	• Raise awareness among the project workers and support mechanisms to prevent and control spread of communicable diseases among the project workers and local communities. • To prevent infectious diseases such as HIV/AIDS, provide regular training to workers.	Contractor / KenGen	KenGen	6,194,000
13	Working environment	Impact on the labor force	• Put in place mechanisms to deter the work force from engaging in poaching of wildlife and cutting down trees for fuel wood, charcoal burning and building material. • Use prefabricated material (which can later be retrieved at the end of the project) in building the labour camps. • When noise levels exceed 85-90 dBA, protective hearing equipment such as earplugs or earmuffs shall be provided to workers.	Contractor	KenGen	Included in the cost

Table 5-1. Mitigation measures and cost (Construction stage)

Parameters		Impact	Mitigation measures	Responsibility		Estimated Cost (KES)
				Implementing Organization	Supervising Organization	
			• Promote training workers and check work procedures on the use of protective equipment, including masks and earplugs.			
14	Accident	Increase in accidents and occupational injuries	• Design and implement safety measures and emergency plans to contain accident risks. • Evacuation drills will be conducted regularly in anticipation of emergencies such as large-scale fires and explosions. • Install appropriate road traffic signs, markings and road furniture on the rehabilitated road. • Provide workers with protective clothing (nose and mouth masks, earmuffs, overalls, industrial boots and gloves) and helmets as applicable.	Contractor	KenGen	Included in the cost

Table 5-2. Mitigation measures and cost (Operation period)

Parameters		Impact	Mitigation measures	Implementing Organization	Responsible Organization	Estimated Cost (KES)
1.Pollution						
1	Water Quality	Impact on soil and waterbodies	• Regularly monitor the water quality of effluent discharged from the power plant site.	KenGen	KenGen	2,500,000/year
2	Waste	Impact on land, water bodies and the environment	• Use suitable human waste disposal systems solar and pit latrines as found appropriate. • Segregate solid waste in the RE, Contractor and labour camp units and arrange for subsequent disposal through either efficient incineration or disposal in an approved dump or in a sanitary landfill. Management of appropriate disposal of industrial waste.	KenGen	KenGen	8,000,000
3	H_2S	Impact on residents' lives and the environment	• Monitor H_2S	KenGen	KenGen	1,000,000/year
4	Noise and Vibration	Impact on residents' lives and the environment	• Monitor noise levels.	KenGen	KenGen	Included in the operation cost
2.Natural Environment						

5	Protected area (National Park) / Fauna, flora, and biological diversity	Habitat and biodiversity loss	• Discourage any wanton destruction of vegetation and habitats beyond the designed project works. • Restore lost biodiversity on the disturbed area through planting of appropriate trees, shrubs and grasses and protection of fauna species and their habitat. • Identification and mapping of invasive species, primarily through uprooting before flowering. • Participation in monitoring and biodiversity investigations with other stakeholders including KWS and KMFRI. • Increase surveillance and security in Hell's Gate National Park during the construction stage. • Support for local initiatives in environmental protection.	KenGen	KenGen	Included in the operation cost
3.Social Environment						
6	Landscape	Loss of Landscape	• Rehabilitate all degraded areas through landscaping and subsequent planting of suitable grass, shrubs and trees to blend with the environment. • Paint the power plant and other project buildings and the steam pipelines with appropriate colours.	KenGen	KenGen	Included in the operation cost
7	Infectious diseases such as HIV/AIDS	Increase in the prevalence of communicable diseases such as HIV/AIDS	• Raise awareness among the project workers and support mechanisms to prevent and control spread of communicable diseases among the project workers and local communities. • To prevent infectious diseases such as HIV/AIDS, provide regular training to workers.	KenGen	KenGen	3,000,000/year

8	Working environment	Impact on the labor force	• Put in place mechanisms to deter the work force from engaging in poaching of wildlife and cutting of trees for fuel wood, charcoal burning and building material. • Use prefabricated material (which can later be retrieved at the end of the project) in building the labour camps. • Promote training workers and check work procedures on the use of protective equipment, including masks and earplugs.	KenGen	KenGen	5,000,000/year
9	Accident	Increase in accidents and occupational injuries	• Design and implement safety measures and emergency plans to contain accident risks. • Evacuation drills will be conducted regularly in anticipation of emergencies such as large-scale fires and explosions. • Install appropriate road traffic signs, markings and road furniture on the rehabilitated road. • Provide workers with protective clothing (nose and mouth masks, earmuffs, overalls, industrial boots and gloves) and helmets as applicable.	KenGen	KenGen	7,000,000/year

6 ENVIRONMENTAL MONITORING PLAN (EMOP)

Based on the above-mentioned mitigation measures, the Team developed the draft Environmental and Social Monitoring Plan which contains the items needed for monitoring as shown below, such as monitoring items, location and frequency, and the responsible body. The Environmental and social monitoring results will be compiled into an annual report and submitted to NEMA.

The Environmental and Social Monitoring Form is attached.

The project area is adjacent to Hell's Gate National Park, and mitigation measures are being considered to prevent impacts on the national park during construction and operation, but it is necessary to properly implement the following monitoring plan.

Table 6-1. Environmental monitoring plan (Construction stage）

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsibility	
						Implementing body	Supervising body
Air pollution	• watering of access routes, construction sites, deviations and other disturbed sites • covering lorries transporting construction materials.	• Complaints from local residents • number of water bowsers used	—	• Along the access roads, at borrow pit sites	Weekly	Contractor	KenGen
	• Provide workers with appropriate dust protective gear, including masks and overalls.	• Number and type of dust protective gear supplied to the labour force.	EHS	• Other sites where project work are taking place.	Weekly	Contractor	KenGen
Water quality	• Confirm that septic tanks are functioning properly and are undamaged. • Monitor the quality of wastewater discharged from labour camps.	• Operation status of the septic tank • Monitoring parameters: Temperature, pH, TSS, BOD_5, COD, TN, TP, Oil and Grease	Law in Kenya, EHS	• labour camps • Effluent outlet from the campsite.	Monthly	Contractor	KenGen
Waste	• Management of appropriate disposal of industrial waste	• Waste tracking sheet	—	• Waste collection yard	Monthly	Contractor	KenGen
	• Use suitable human waste disposal systems, solar and pit latrines as found appropriate • Segregate solid waste in the RE, Contractor and labour camp units and arrange for subsequent disposal through either efficient incineration or disposal in an approved dump or in a sanitary landfill.	• Number of WC, solar and pit latrines constructed • Number of solid waste receptacles installed • Number and type of incinerators installed • Approved sanitary landfill / dump facility identified and utilized.	Law in Kenya, EHS	• In the Resident Engineer/Contractor camps and labour camp units	Wekkly	Contractor	KenGen

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsibility	
						Implementing body	Supervising body
Noise and Vibration	• Use of protective hearing devices such as ear plugs and earmuffs among project workers when noise levels exceed 85-90 dBA. • Selection of appropriate machinery and regular service of machinery and vehicles. • Monitor noise levels.	• Number of complaints from local residents • Noise levels recorded • Number and type of protective hearing devices dispensed to workers. • Noise level monitoring	• EHS guideline • EHS	• Project constriction site • Nearest communities/resident	Weekly	Contractor	KenGen
Protected area (National Park)/Fauna and Flora	• Regular monitoring of wildlife numbers • Participation in monitoring and biodiversity investigations with other stakeholders including KWS and KMFRI	• Implementation status of mitigation measures	• MoU • NP Management Plan	• At the power plant site, along the access roads and transmission lines in quarries and borrow pits and other areas where biodiversity has been destroyed. • Around the National Park	Quarterly	Contractor	KenGen

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsibility	
						Implementing body	Supervising body
	• Controlling the entry of project workers • Installation of speed limits and erection of bump and transmission lines which allow the passage of animals, and fences around the brine ponds • Consider implementing the installation of wire markers on the transmission lines and ensuring sufficient spacing between them to prevent bird electrocution as needed. • Discourage any wanton destruction of vegetation and habitats beyond the designed project works. • Restore lost biodiversity on the disturbed area through planting of appropriate trees, shrubs and grasses and protection of fauna species and their habitat. • Identification and mapping of invasive species, primarily through uprooting before flowering. • Increase surveillance and security in the Hell's Gate National Park during the construction stage	• Implementation status of mitigation measures • Number of tree nurseries established • seedlings planted in the disturbed areas • Number of disturbed sites rehabilitated • extent eradication of alien species.	• MoU • NP Management Plan	• At the power plant site and transmission line, in quarries and borrow pits and other areas where biodiversity has been destroyed. • Around the National Park	Weekly	Contractor	KenGen

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsibility	
						Implementing body	Supervising body
Soil erosion	• Where applicable, install silt traps to reduce sediment load directly entering riverine environments. • Carry out terracing and landscaping of the disturbed sites as appropriate. • Plant sediment binding grasses, shrubs and trees on the exposed slopes and other surfaces as appropriate.	• Implementation status of mitigation measures • Number of silt traps • Number of sites landscaped • Levels of turbidity recorded in the silt receiving waters/ areas.	—	• In disturbed sites where there are cuts and fills in the vicinity of bridges and culverts, around borrow pits and exposed slopes.	Weekly	Contractor	KenGen
Landscape	• Rehabilitate all degraded areas through landscaping and subsequent planting of suitable grass, shrubs and trees to blend with the environment. • Paint the power plant and other project buildings and the steam pipelines with appropriate colours	• Implementation status of mitigation measures • Number of sites landscaped and terraced • Number and type of trees and shrubs and amount of grass planted.	—	• Along the rehabilitated road, access roads, along the steam pipelines, around borrow pit sites and other sites that have been affected by project activities.	Weekly	Contractor	KenGen
Misdistribution with unfair distribution of benefits and damages	• The Employment Subcommittee will share information and discuss employment opportunities for local residents.	• Jobs are available for local people and hired number by area.	—	• Project site and surrounding communities	Quarterly	Employment Subcommittee	KenGen

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsibility	
						Implementing body	Supervising body
Cultural contamination	• Conduct awareness training for project workers on local customs and cultural practices. • Educate workers and local residents about STI (sexually transmitted infections) and HIV/AIDS. • Contractors shall inform workers about local culture and STI risks. • Develop an HIV and Culture Prevention Program in accordance with KenGen's HIV/AIDS and EHS policies and include it in the bid documents. • Contractors shall develop and implement an HIV and Culture Prevention Program in accordance with KenGen's program.	• Number of training sessions and content • Number of education sessions for workers and local residents about STIs and the risks associated with them. • Confirm whether the HIV and Culture Prevention Program is being created.	—	• Project site and surrounding communities,	Quarterly	Contractor	KenGen
Health / Public health	• Temporary toilets will be installed and sewage will be treated	• Implementation status of mitigation measures	• Law in Kenya, • EHS	• Construction site	Quarterly	Contractor	KenGen

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsibility	
						Implementing body	Supervising body
Infectious diseases such as HIV/AIDS	• Raise awareness among the project workers and support mechanisms to prevent and control spread of communicable diseases among the project workers and local communities	• Implementation status of mitigation measures	• EHS	• Urban settlement in project area • labour camps • residential areas of senior project workers • community areas of Kamere, Narasha, Ol Maiyana Kubwa RAP Land and other settlements around Lake Naivasha.	Quarterly	Contractor	KenGen
Promoting local employment and economy	• Implementation of vocational training to promote employment of local residents. • Support for the Local community including Maasai. • Consider gender equality in employment	• Contents of the implemented vocational training: - Number of sessions; - Target participants; - Number of participants; - Gender and age of participants; • Details of support for the community. • Number of local residents and women employed	_	• Communities around project area	Once a year	Contractor	KenGen
Gender and Child Labor	• Provide workers with training to prevent issues such as gender discrimination and child labor.	• Training content, number of sessions, and participants	_	• Project site	Quarterly	Contractor	KenGen

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsibility	
						Implementing body	Supervising body
Local community including Maasai	• Support for the local community including Maasai	• Number of new workers employed. • Number of vocational training sessions and their content.		Local community including Maasai	Quarterly	Contractor	KenGen
Working environment	• Provide workers with protective clothing (nose and mouth masks, earmuffs, overalls, industrial boots and gloves) and helmets as applicable	• Number of complaints from workers and local community • Number and type of protective clothing and gear provided to workers. • Audit by Health and Safety Committee	• EHS	• Construction site, Worker's camp	Quarterly	Contractor	KenGen
		• Monitoring of noise	• Law in Kenya	• Construction site, Worker's camp	Weekly	Contractor	KenGen
Accidents	• Design and implement safety measures and emergency plans to contain accident risks. • Install appropriate road traffic signs, markings and road furniture on the rehabilitated road.	• Implementation status of mitigation measures • Number of traffic accidents	• EHS	• Along the roads to be rehabilitated, borrow pits, within the power plant facility and other sites of the project area where project activities will be taking place.	Monthly	Contractor	KenGen

1) Monitoring costs are included in the costs of mitigation measures

Table 6-2. Environmental monitoring plan (Operation period)

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsible Implementing body
Water quality	• Monitor the water quality of effluent discharged from the power plant site.	Monitoring parameters: Temperature, pH, TSS, BOD_5, COD, TN, Cd, As, Oil and Grease	• Law in Kenya.	• Drainage ditch Note: Drainage ditches may not normally have flowing water, but sampling should be conducted when drainage occurs, such as during rainfall.	Irregular basis (when effluent occurs in the ditch)	KenGen
Waste	• Management of appropriate disposal of industrial waste	• Waste tracking sheet	—	• Waste collection yard	Monthly	KenGen
	• Use suitable human waste disposal systems, solar and pit latrines as found appropriate • Segregate solid wastes in the RE, Contractor and labour camp units and arrange for subsequent disposal through either efficient incineration or disposal in an approved dump or in a sanitary landfill.	• Number of WC, solar and pit latrines constructed • Number of solid waste receptacles installed • Number and type of incinerators installed • Approved sanitary landfill / dump facility identified and utilized.	—	• In the Resident Engineer/Contractor camps and labour camp units	Monthly	KenGen
Noise and Vibration	• Monitor noise levels.	• Number of complaints from local residents • Noise level monitoring	• EHS guideline	• Power plant premise and facing communities/residential boundaries • Nearest communities/resident	Monthly	KenGen

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsible Implementing body
H_2S	• H_2S concentration monitoring	• Number of complaints from local residents • H2S concentration monitoring	• WHO and EHS guideline	• Power plant premise and facing communities/residential boundaries • Nearest communities/resident	Monthly	KenGen

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsible Implementing body
Protected area (National Park) / Fauna and Flora	• Regular monitoring of wildlife numbers • Participation in monitoring and biodiversity investigations with other stakeholders including KWS and KMFRI	• Implementation status of mitigation measures	—	• At the power plant site and transmission line, in quarries and borrow pits and other areas where biodiversity has been destroyed. • Around the National Park	Quarterly	KenGen
	• Controlling the entry of project workers • Installation of speed limits and erection of bump, drains, steam pipelines and loops which allow the passage of animals, and fences around the brine ponds • Discourage any wanton destruction of vegetation and habitats beyond the designed project works. • Restore lost biodiversity on the disturbed area through planting of appropriate trees, shrubs and grasses and protection of fauna species and their habitat. • Identification and mapping of invasive species, primarily through uprooting before flowering.	• Implementation status of mitigation measures • Number of tree nurseries established • seedlings planted in the disturbed areas • Number of disturbed sites rehabilitated • extent of eradication of alien species.	—	• At the power plant site and transmission line, in quarries and borrow pits and other areas where biodiversity has been destroyed. • Around the National Park	Weekly	KenGen

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsible Implementing body
Landscape	• Rehabilitate all degraded areas through landscaping and subsequent planting of suitable grass, shrubs and trees to blend with the environment. • Paint the power plant and other project buildings and the steam pipelines with appropriate colours	• Implementation status of mitigation measures • Number of sites landscaped and terraced • Number and type of trees and shrubs and amount of grass planted.	—	• Along the rehabilitated road, access roads, along the steam pipelines, around borrow pit sites and other sites that have been affected by project activities.	Weekly	KenGen
Infectious diseases such as HIV/AIDS	• Raise awareness among the project workers and support mechanisms to prevent and control spread of communicable diseases among the project workers and local communities	• Implementation status of mitigation measures for HIV/ AIDS	—	• Urban settlement in project area • labour camps • residential areas of senior project workers • community areas of Kamere, Narasha, Ol Maiyana Kubwa RAP Land and other settlements around Lake Naivasha.	Quarterly	KenGen
Promoting local employment and economy	• Implementation of vocational training to promote employment of local residents. • Consider gender equality in employment	• Contents of the implemented vocational training: - Number of sessions; - Target participants; - Number of participants; - Gender and age of participants; • Details of support for the community. • Number of local residents and women employed	—	• Communities around project area	Once a year	KenGen

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsible Implementing body
Local community including Maasai	• Support for the local community including Maasai	• Number of new workers employed. • Number of vocational training sessions and their content. • New scholarships for underprivileged students. • Development of new markets for expanding sales of handicrafts	—	• Communities surrounding the power plant including Maasai	Once a year	KenGen

Environmental Parameters	Mitigation measures	Contents	Standard	Location	Frequency	Responsible Implementing body
Working environment	• Provide workers with protective clothing (nose and mouth masks, earmuffs, overalls, industrial boots and gloves) and helmets as applicable	• Number of complaints from workers and local community • Number and type of protective clothing and gear provided to workers. • Audit by Health and Safety Committee	—	• Construction site, Worker's camp	Quarterly	KenGen
		• Monitoring noise • Monitoring H_2S	• Law in Kenya	• Several locations on the Power Plant site	Continuous measurement weekly or Daily	KenGen
Accidents	• Design and implement safety measures and emergency plans to contain accident risks. • Install appropriate road traffic signs, markings and road furniture on the rehabilitated road.	• Implementation status of mitigation measures • Number of traffic accidents;	—	• Along the roads to be rehabilitated, borrow pits, within the power plant facility and other sites of the project area where project activities will be taking place.	Monthly	KenGen
	• Conducting evacuation drills, inspecting fire extinguishing equipment	• Implementation status of mitigation measures	—	• Power Plant	Quarterly	KenGen
	• Inspection of the geothermal fluid pipeline, NCG gas pipeline, and waste machine oil storage conditions • Monitoring of brine pipeline leakage	• Check for leakage • Monitor changes in the surrounding environment visually around the brine pipeline	—	• Power Plant • Around the brine pipeline	Monthly	KenGen

1) Monitoring costs are included in the costs of mitigation measures

7. RESULT OF THE MEETING WITH THE MAASAI PEOPLE HELD BY JICA'S STUDY TEAM IN JULY 2024

JICA's study team held a meeting with representatives of the Maasai community. The purpose of the meeting was to confirm their concerns about this project and the impact of existing power generation facilities on the Maasai community.

Table 8-1. Result of the meeting

Item	Result of the meeting
Outline	Implementation period: July 2024 Frequency: once Location: Geothermal Plaza in Olkaria Method: face-to-face interview Notification method: Contact from KenGen staff Number of participants : 16 (male 12, female 4) Language used: Maasai language
Summary of the responses	The following responses were obtained through interviews conducted by JICA's study team: - All representatives clearly expressed their full support for this project. - Regarding access to KenGen in case of complaints from residents, KenGen has a local community liaison office with dedicated staff. Residents can file complaints with the KenGen local community liaison office staff through community representatives at any time, and KenGen is prepared to respond promptly. - KenGen provides employment opportunities to the community. - KenGen has installed water supply facilities in the community and provides water to residents free of charge. - KenGen provides school buses so that community children can attend school and awards scholarships to bright and needy students for secondary and university education. -KenGen rehabilitate the roads and provide children with transport to Mvuke primary school - There have been no impacts from existing power plants and related facilities. - Although there has been a decrease in grazing land due to development, KenGen allows grazing within its own land, so the impact is limited. - KenGen provides support to the Maasai Culture Center. Examples include providing land for the Maasai Culture Center, supporting training for making handicrafts, and finding markets to expand sales of handicraft products. From the above, it can be concluded that KenGen has built a good relationship with the Maasai community, actively supports the community, and has established a complaint mechanism, so the project is expected to have a large positive impact on the Maasai community.  Figure. Meeting with representatives of the Maasai community around the project site by the JICA's survey team (Photo by JICA's survey team in July 2024)

8. GRIEVANCE ASSESSMENT, RESOLUTION AND RESPONSIBILITIES

The overall flow of the grievance mechanism is shown in Figure 8.1.

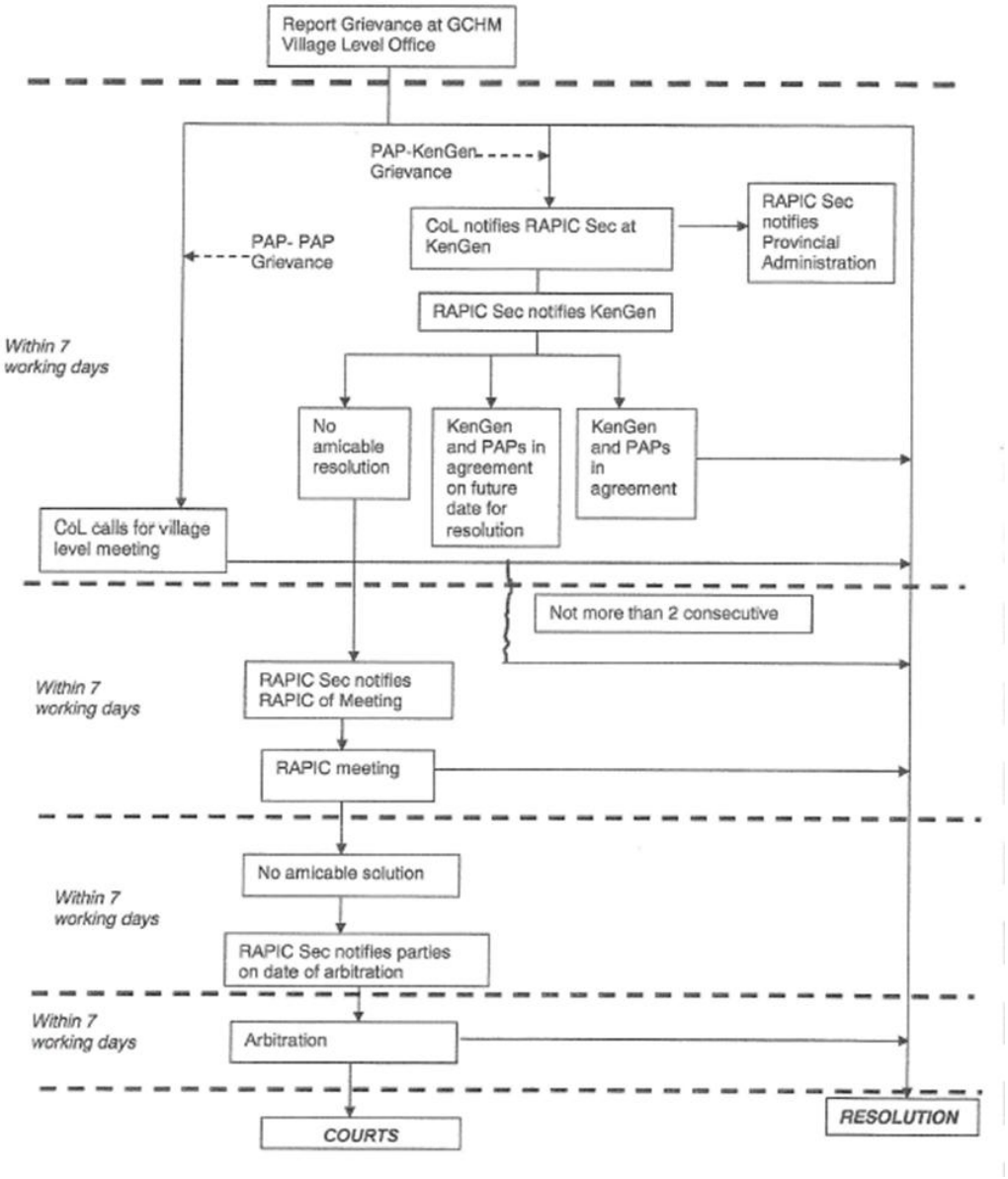


Figure 8.1 Grievance and Conflict Resolution Mechanism（GCHM）

Grievance assessment and resolution activities are carried out in the following main steps:

- Submission by stakeholders;
- Logging a grievance;
- Providing the response;
- Investigating the grievance;
- Concluding/resolving the root cause of the grievance; and
- Taking further steps if the grievance remains open.

8.1 SUBMISSION OF GRIEVANCE BY STAKEHOLDERS

A grievance can be submitted to KenGen in a number of ways as listed below:

- During regular public meetings held with the communities;
- Through consultative forums with stakeholders;
- Through the community thematic committees established with KenGen;
- During any informal meetings;
- Through communication directly with management;
- By telephone or e-mail;
- Placing a comment in the community suggestion boxes at the Health, Safety and Environment (HSE) Manager / Community Liaison Officer; and
- By registering a complaint in a Grievance and Concerns logging form as shown at the Appendices below.

8.2 LOGGING A GRIEVANCE

Complaints are received in form of oral/written, mail and phone. All complaints must be logged by using the Grievance/Feedback form and registered in the Grievance/Concerns register upon receipt (See the Appendices).

8.3 PROVIDING A RESPONSE

All grievances will be acknowledged within 5 days. If immediate corrective action is available, response will also be given within the 5 days. Where no immediate corrective action is available but no detailed investigations/hearings are required, a response will be provided within 14 days. In all the cases, it must be explained in writing to the aggrieved party. KenGen will categorize grievances based on validity and risk criteria as outlined below:

- External/Frivolous cases - having nothing to do with the project
- Urgent
- Important

8.4 INVESTIGATING A GRIEVANCE

If a grievance has to be investigated, the HSE Manager/ Liaison Officer shall aim to complete investigation within two weeks after the grievance first log-in. Depending on the nature of the grievance, the approach and personnel involved in the investigation will vary. The HSE manager/ Community Liaison Officer will meanwhile continually update the aggrieved on the progress of the investigation and the timeline for its conclusion.

8.5 Concluding/resolving the root cause of a grievance

Putting into consideration the lessons learnt, the HSE Manager/ Liaison Officer will outline the steps taken to ensure that the grievance does not re-occur.

8.6 TAKING FURTHER STEPS IF A GRIEVANCE REMAINS OPEN

If the grievance still stands, then the HSE Manager/ Liaison Officer will initiate further investigation and determine the steps for future action. In the meanwhile, the community will be updated about the process through the area local Chief/thematic committee/KenGen.

8.7 GRIEVANCE REPORTING CHANNELS

Reporting channels for the KenGen Grievance Redress Mechanism (GRM) are summarized below as follows:

- Establish a dedicated GRM desk at the Olkaria VII project sites, KenGen offices or other accessible location managed by GRM Coordinators;
- Provide a grievance box at the above locations;
- Designate a focal GRM person to receive, log grievances and pass them over to the respective committee;
- Establish a dedicated email address or online form for submitting grievances;
- Provide a mobile phone hotline/SMS system for reporting grievances;
- Provide grievance reporting forms and information in local languages; and
- Provide assistance to those who need help filling out forms or submitting grievances.

8.8 ROLES AND RESPONSIBILITIES FOR THE KENGEN GRM

KenGen developed GRM shall be published to ensure that all stakeholders are aware of the existence of the GRM and the way it will be used to resolve grievances. KenGen experts including Community Liaison Officer (CLO), Social specialist and HSE Manager will ensure the community stakeholders understand how to raise their grievances in a timely and effective way. Below is a summary of key roles and responsibilities for the GRM staff.

8.9 COMMUNITY LIAISON OFFICER

- Sensitize all stakeholders on the GRM and ensure continuous awareness / understanding of the GRM existence;
- Participate in Grievance Management meetings;

- Responsible to receive, acknowledge and register grievances submitted by any stakeholder or group for further action;
- Being the bridge between KenGen and the communities he/she will play a key role in the investigation process;
- Ensure the grievance resolution forms are signed off once a grievance is closed;
- Tracking grievances and managing the KenGen complaint/ grievance register;
- Documenting the grievances, working with grievance management committee to resolve grievances, documenting feedback from the PAPs, local community administration, community leaders and community members and reporting to HSE Manager; and
- Provide monthly reports comprising of any issues identified or grievances reported, details / minutes of any major meetings or engagements held with any key stakeholders regarding the GRM, among other responsibilities.

8.10 SOCIAL SPECIALIST

- Promote awareness and understanding of the existence and purpose of the GRM;
- Fully responsible in the management and implementation of the GRM;
- Participate in receiving, acknowledging and registering grievances;
- Implementing and supervising Grievance Redress Mechanism;
- Follow up with senior management on grievances remedial actions to ensure timely closure;
- Liaise with HSE Manager and follow up on extra resources required for running the GRM;
- Participate as a main custodian of all the GRM grievance documents, and ensure confidentiality in sharing information with the relevant parties or individuals;
- Support the KenGen Community Liaison Officer to resolve grievances in an amicable manner with a view to achieving a mutually acceptable solution;
- Tracking grievances and managing the KenGen GRM complaint/ grievance register;
- Participate in documenting grievances, working with grievance management committee to resolve grievances, documenting feedback from the PAPs, local community administration and community leaders and community members.
- Participate in the update of grievance registers and prepare a final monthly report;
- Provide regular reports on the performance of the GRM, including the number of grievances received, the types of grievances, and the outcomes of resolutions; and
- Share information about the GRM and its performance with the community and other relevant stakeholders.

8.11 HSE MANAGER

- Review and monitor the grievance redress resolution and inform the KenGen Board of Directors;
- Identify and train individuals to manage the GRM process;
- Secure adequate funding to support the operation of the GRM;
- Provide technical advice on unresolved grievances while approving budgets where necessary to facilitate timely grievance closure;
- Ensure that those responsible for the GRM are accountable for its performance; and
- Regularly monitor and evaluate the effectiveness of the GRM and make necessary adjustments.

Environment and Social Monitoring Form (Pre-Construction Phase)

(1) General

1) Phase of the Project

- Please mark the current phase.

□ Pre-Construction Phase **□ Construction Phase** **□ Operation Phase**

2) Obtainment of Environmental Permits

Name of permits	Expected issuance date	Actual issuance date	Concerned authority	Remarks (Conditions, etc.)
Attached approval letter:				

3) Response/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period	Duration of Report Period	Frequency
Number and contents of formal comments made by the public		1 Day	Upon receipt of comments/complaints
Number and contents of responses from Government agencies			

(2) Monitoring Results

1) Misdistribution with unfair distribution of benefits and damages

Item	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Jobs available for local people and hired number by area.		

2) Working environment

Item	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Number of complaints from workers and local community		
Audit by Health and Safety Committee		

(End)

Environment and Social Monitoring Form (Construction Phase)

(1) General

1) Phase of the Project

- Please mark the current phase.

□ Pre-Construction Phase **□ Construction Phase** **□ Operation Phase**

2) Obtainment of Environmental Permits

Name of permits	Expected issuance date	Actual issuance date	Concerned authority	Remarks (Conditions, etc.)
Attached approval letter:				

3) Response/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period	Duration of Report Period	Frequency
Number and contents of formal comments made by the public		1 Day	Upon receipt of comments/complaints
Number and contents of responses from Government agencies			

Complaints about the entire project (number of complaints, content)	Countermeasures

Summary of Stakeholder Consultations (Date, Attendees)	Content of the discussions

(2) Monitoring Results

1) Air pollution

Complains from Residents

- Are there any complaints from residents regarding air quality during this monitoring period? □ Yes, □ No

If yes, please describe the contents of complaints and the countermeasures taken in the table below.

Contents of Complaints from Residents	Countermeasures

Number of water bowsers used

Item	Status
Number of water bowers used	

Number and type of dust protective gear supplied to the labour force.

Location	Type of dust protective gear	Numbers	Note

2) Waste

Industrial waste tracking sheet

Month	Confirmation	Note (issues to be arisen and its measures, if any)

Waste

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Number of WC, solar and pit latrines constructed		
Number of solid waste receptacles installed		
Number and type of incinerators installed		
Approved sanitary landfill / dump facility identified and utilized.		

3) Noise and Vibration

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Number of complaints from local residents		
Number. and type of protective hearing devices dispensed to workers.		
Noise monitoring results		

*Reference Value: EHS guideline
Measurement Frequency: Weekly
Measurement Location: Project constriction site, nearest communities/residents

4) Water quality[1]

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Temperature, pH, TSS, BOD5, COD, TSS, TN, TP, Oil and Grease		

*Reference values: Law in Kenya, EHS
Measurement frequency: Monthly
Measurement location: Labor camps, Effluent outlet from the campsite.

5)Protected area (National Park)

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		
Number of tree nurseries established		
Seedlings planted in the disturbed areas		
Number of disturbed sites rehabilitated		
extent of eradication of alien species.		

6) Fauna and Flora

Item	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		
Number of tree nurseries established		
Seedlings planted in the disturbed areas		
Number of disturbed sites rehabilitated		
extent of eradication of alien species.		

7) Soil erosion

Item	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		
Number of silt traps		
Number of sites landscaped		
Levels of turbidity recorded in the silt receiving waters/ areas.		
Implementation status of mitigation measures		

8) Landscape

Item	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		
Number of sites landscaped and terraced		
Number and type of trees and shrubs and amount of grass planted.		

9) Misdistribution with unfair distribution of benefits and damages

Item	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Jobs available for local people and hired number by area.		

10) Cultural contaminnation

Item	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Number of training sessions and content.		
Number of education sessions for workers and local resident about STIs and the risks associated with them.		
Confirm whether the HIV and culture Prevention Program is being created.		

11) Health / Public health

Item	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		

12) Infectious diseases such as HIV/AIDS

Item	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		

13) Working environment

Item	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Number of complaints from workers and local community		
Number and type of protective clothing and gear provided to workers.		
Audit by Health and Safety Committee		
Monitoring of noise		

14) Accidents

Item	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		
Number of traffic accidents;		

15) Promoting local employment and economy

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Contents, number of sessions, target participants, number of participants, and the gender and age of those participating in the implemented vocational training.		
Details of support for the community		

16) Gender and Child Labor

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Training content		
Number of sessions and participants		

17) Local community including Maasai

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Number of new workers employed.		
Number of vocational training sessions and their content.		
New scholarships for underprivileged students.		
Development of new markets for expanding sales of handicrafts.		

(End)

Environment and Social Monitoring Form (Operation Phase)

(1) General

1) Phase of the Project

- Please mark the current phase.

□ Pre-Construction Phase **□ Construction Phase** **□ Operation Phase**

2) Obtainment of Environmental Permits

Name of permits	Expected issuance date	Actual issuance date	Concerned authority	Remarks (Conditions, etc.)
Attached approval letter:				

3) Response/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period	Duration of Report Period	Frequency
Number and contents of formal comments made by the public		1 Day	Upon receipt of comments/complaints
Number and contents of responses from Government agencies			

(2) Monitoring Results

1) Waste

Industrial waste tracking sheet

Month	Confirmation	Note (issues to be arisen and its measures, if any)

Waste

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Number of WC, solar and pit latrines constructed		
Number of solid waste receptacles installed		
Number and type of incinerators installed		
Approved sanitary landfill / dump facility identified and utilized.		

2) Noise and Vibration

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Number of complaints from local residents		
Noise levels recorded		
Monitoring of noise		

*Reference Value: EHS guideline

Measurement Frequency: Monthly

Measurement Location: Power plant premise and facing communities/residential boundaries, nearest communities/residential

3) H_2S

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Number of complaints from local residents		
H_2S monitoring results		

*Reference values: WHO, EHS guidelines
Measurement frequency: Monthly
Measurement locations: Power plant premise and facing communities/residential boundaries, nearest communities/residential

4) Water quality[1)]

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Temperature, pH, TSS, BOD5, COD, TSS, TN, Cd, As, Oil and Grease		

*Reference values: Kenya Law, EHS
Measurement frequency: Irregular basis (When discharging occurs)
Measurement location: Drainage ditch (Note: Drainage ditches may not normally have flowing water, but sampling should be conducted when drainage occurs, such as during rainfall.)

5)Protected area (National Park)

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		
Number of tree nurseries established		
seedlings planted in the disturbed areas		
Number of disturbed sites rehabilitated		
extent of eradication of alien species.		

6) Fauna and Flora

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		
Number of tree nurseries established		
seedlings planted in the disturbed areas		
Number of disturbed sites rehabilitated		
extent of eradication of alien species.		

7) Landscape

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		
Number of sites landscaped and terraced		
Number and type of trees and shrubs and amount of grass planted.		

8) Infectious diseases such as HIV/AIDS

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		

9) Working environment

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Number of complaints from workers and local community		
Number and type of protective clothing and gear provided to workers.		
Audit by Health and Safety Committee		
Monitoring of noise		
Monitoring of H_2S		

10) Accidents

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Implementation status of mitigation measures		
Number of traffic accidents;		
Implementation status of mitigation measures		
Check for leakage		

11) Promoting local employment and economy

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Contents, target participants, number of sessions, number of participants, the gender and age of those participating in the implemented vocational training.		
Details of support for the community		

12) Local community including Maasai

Parameters	Monitoring Results during Report Period	Note (issues to be arisen and its measures, if any)
Number of new workers employed		
Number of vocational training sessions and their content		
New scholarships for underprivileged students		
Development of new markets for expanding sales of handicrafts		

(End)