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Title: **Technical Specification for operator training simulator replacement.**

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CONTENTS

1. INTRODUCTION

This document details the technical specifications for the replacement of the operator training simulator at Grootvlei Power Station. The technical specifications will form an integral part of the Works Information document that will be sent out to the Tenderer to tender on.

The current installed training simulator at Grootvlei Power Station was installed during RTS and has been running with major defects that emanated from bad implementation of the initial simulator project. The current simulator is in the non-functional state and in addition, the OEM of the currently installed Operator Training Simulator (OTS) has indicated that this system has reached its end of life and has no technical support as the number of engineers that were skilled on the legacy system has diminished. Given these major challenges, the training department has not been able to perform any of the training scenarios. This is impacting on the development of operators as they are unable to perform refresher training, conduct or replicate the real plant scenarios as part of operational experience, this presents a risk of increased unit trips due to operator error. C&I Engineers are also unable to implement and test system changes on the OTS system before making permanent changes on the running units.

In order to mitigate this risk, the current operator training simulator will need to be replaced with a new, properly supported and functioning system that will improve the training environment for the operators and for C&I personnel to test control changes prior to implementing them on the running units. Grootvlei Power Station was first commissioned between 1969 and 1977 and then decommissioned (mothball) in 1990 due to excess power at that time. It was later recommissioned between 2006 and 2011. The power plant has four 200MW and two 190MW units manufactured by different suppliers. Grootvlei Power Station was first planned to be decommissioned in financial year 2022/2023 due to high maintenance costs, low thermal efficiency and due to it reaching its useful life (50th year operational for coal fired power plant). However, the station operational life was extended to 2029/30 financial years and thereafter it will be shut down. Currently units 1,2 and 3 are operational with units 4,5 and 6 on extended cold reserve with no plans of recommissioning them. The site is thereafter earmarked for repurposing and repowering with power generation from renewable energy. Feasibility studies are currently underway.

2. SUPPORTING CLAUSES

2.1 SCOPE

This document specifies the minimum technical requirements that will need to be met with the design, procure, supply, installation and commissioning of the new operator training simulator Projec*t* at Grootvlei Power Station.

2.1.1 Purpose

The purpose of this document is to define the technical component of the Works Information that will be used by the *Contractor* to compile a detail design report and thereafter tender for the proposed works.

2.1.2 Applicability

This document is applicable to Grootvlei Power Station for design, procure, supply, installation and commissioning of the new operator training simulator project.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] ISO 9001, Quality Management System

[2] Process Control Manual to Optimise Operator Training and Maintain Quality of Training. 32-1314

[3] 36-1422 User Requirement Specification for Fossil Fired Power Plant Simulators

[4] 240-154243686 Technical Requirements for Power Plant Simulators Standard

[5] 240-158191826 Generation Operation Training Requirements Specification for Power Plant Simulator

[6] 240-29618594 Milling Plant Maintenance Philosophy.pdf

[7] 240-29824872 Main Steam Pipework Maintenance Philosophy Unit 1-6.pdf

[8] 240-30606698 Unit 1-4 and 6 Boiler Pressure Parts Maintenance Philosophy.pdf

[9] 240-31585274 Raw Water Supply, Operating and Control Philosophy.pdf

[10] 240-35071978 Babcock 8.5E Grind Elements Philosophy.pdf

[11] 240-35596596 Ash Plant Operating and Control Philosophy.pdf

[12] 240-36789337 Unit 5 Boiler Pressure Parts Maintenance Philosophy.pdf

[13] 240-37501287 FG01 Operating and Control Philosophy.pdf

[14] 240-37590672 Unit 1 to 6 Soot blower Maintenance.pdf

[15] 240-37765157 FG05 Control Philosophy for Draught System unit 1-6.pdf

[16] 240-37765165 FG01 Boiler Protection Philosophy Unit 1,2,3,4..pdf

[17] 240-37765175 FG04 Mills System Control Philosophy Unit 1-4&6.pdf

[18] 240-37765182 FG10 Control Philosophy For Feedwater System Unit 1.pdf

[19] 240-37765184 FG14 Control Philosophy for Stator Coolant System Unit 1.pdf

[20] 240-37765211 FG05 Draught Group System Control Philosophy Unit 2.pdf

[21] 240-37765214 FG04 Mills System Control Philosophy Unit 2.pdf

[22] 240-37765230 FG10 Control Philosophy Feedwater System Unit 2.pdf

[23] 240-37765248 FG14 Stator Coolant System Control Philosophy Unit 1-6.pdf

[24] 240-38823880 FG14 Control Philosophy for Generator Seal Oil Group Unit 1.pdf

[25] 240-38823903 FG14 Control Philosophy for Generator Seal Oil Group Unit 2.pdf

[26] 240-38823904 FG 14 Control Philosophy for Generator Seal Oil Group Unit 3.pdf

[27] 240-38823909 FG 14 Control Philosophy for generator Seal Oil Group Unit 4.pdf

[28] 240-41118628 Condensate Control Philosophy (Unit 1 to 4).pdf

[29] 240-43474684 Boiler 1-6 Inspection Philosophy.pdf

[30] 240-45725139 FG06 Sootblower System Control Philosophy Unit 1-6.pdf

[31] 240-45725140 FG07 Pressure Parts System Control Philosophy Unit 1-4&6.pdf

[32] 240-46452554 FG10 Control Philosophy for Feedwater Group Unit 5.pdf

[33] 240-60289679 Sergi Ops and Control Philosophy.pdf

[34] 240-64834899 Main Cooling Water System Control & Ops Philosophy.pdf

[35] 240-64940726 Effluent Plant Operating & Control Philosophy.pdf

[36] 240-65096778 WTP Control and Ops Philosophy.pdf

[37] 240-65104396 Coal Plant Control and OPS Philosophy.pdf

[38] 240-72261425 Outage Philosophy for GPS.pdf

[39] GVLEG 0037 Raw Water Supply Operating and Control Philosophy.pdf

[40] GVLEG 0144 Compressor Plant Operating and Control Philosophy.pdf

[41] GVLEG 0174 FG10 Control Philosophy for Feedwater System Unit 6.pdf

[42] GVLEG 0181 Fire Detection system Philosophy.pdf

[43] GVLEG 0234 ASH LINE MAINTENANCE PHILOSOPHY.pdf

[44] GVLEG 0243 Sewage Plant Operating and Control Philosophy.pdf

[45] EWSETA Learning Material Accreditation Guideline

[46] 36-243 Training Delivery Requirements

[47] 36-241 Monitoring and Reporting on Effective of Training and Assessment Activities

[48] 240-46315054 Generation: Evaluation and Effectiveness of Operating Training

[49] 240-46315139 Generation Operator Training Learning Material Development & Authorisation

[50] 240-46315160 Generation: Power Plant Operator Training and Development

[51] 240-46315190 Generation Operator Safety during Training on Equipment in Operation

[52] ANSI/ISA77.20.01-2012 Fossil Fuel Power Plant Simulators – Functional Requirements.

[53] 240-76992014 Project/Plant Specific Technical Documents and Records Management Work Instruction

[54] 559-577223024 Generation Cyber Security Standard for Operational Technology

[55] 240-56355910 Management of Plant Software Standard

[56] 240-159991017 Virtualization of Control Systems Technology Standard

2.3 DEFINITIONS

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

Client: Generation Group, in this case referring to Grootvlei Power Station

Clients Representative: The responsible personnel for the simulator from the reference plant as delegated by the Client

Facilities: buildings, admin and facilitator offices, board rooms, lecture rooms, kitchen facilities and storage areas

Full scope high realism simulator: Is a simulator that fully replicates the reference power plant control room, containing duplicates of the actual operator interface and associated equipment. The unit responses simulated on the simulator are identical in time and response received in the actual reference plant control room under similar conditions. Operator training is thus performed in an environment that is identical to that of the reference power plant.

Generic plant simulator: Is a simulator that is designed to closely replicate an actual power plant control room and controls, but utilise generic simulation models. Operator training is thus performed in an environment that is similar to that of actual power plants.

Operating Co-ordinator: A person appointed in the operator training fraternity who is responsible for the co-ordination of learning delivery and assessment processes and the compliance thereof to accreditation requirements.

Reference plant: The specific fossil fuel power plant the simulator control room configuration, the system control configuration and the simulator database are derived.

Simulation: The mathematical representation/modelling of physical process and control systems.

Standard Equipment: The minimum equipment needed for effective classroom facilitation. This includes but is not limited to a classroom of sufficient size to accommodate learners, a white board, a digital data projector and screen, a LAN compatible PC but preferably a notebook, laser pointers etc.

Training Manager: The person accountable to ensure that the accreditation of the Training Centre is maintained, that all training activities complies with the accreditation requirements, the smooth operation of the training centre and that the buildings and assets under his/her control is maintained in a good state of repair.

Training media: training manuals, DVD's, video tapes etc.

Training Equipment: laptops, DVD player, TV set, , white boards, plant models, camera, safe for the storage of camera and other equipment, electronic and paper based training manuals, audio speakers, computers, monitors, etc.

User: Simulator Instructor

User Requirement Specification: Is a short and to the point document, yet sufficiently comprehensive to clearly and precisely define the type of equipment and systems the Owner/Operator wants, detailing the required performance and functional characteristics, quality, and service performance required. It should further define any non-functional requirements, constraints, and deliverables that need to be supplied with the system. It must also define the legislative and licensing or certification standards and requirements the system and its ancillary structures must or should conform to, as well as any other required reference standards and specifications.

2.3.1 Disclosure Classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
ABAT	As Built Acceptance Test
AP	Application Processor
AWR	Ash Water Return
BFPT	Boiler Feed Pump Turbine (similar to SFTP)
BS	British Standard
CAT	Capability Acceptance Test
C&I	Control & Instrumentation
CCCC	Central Change Control Committee
CPU	Central Processing Unit
1GE	Gigabit Ethernet
BU	Business Unit
C&I	Control and Instrumentation
CoE	Centre of Excellence
CM	Control Module
CPU	Central Processing Unit

Abbreviation	Description
CRA	Concept Release Approval
CW	Cooling Water
DC	Direct Current
DCS	Distributed Control System
DF	Design Freeze
DMZ	Demilitarized Zone
DRA	Definition Release Approval
ECM	Engineering Change Management
EOD	Electrical Operating Desk
EWSETA	Electricity and Water Sector Training Authority
FAT	Factory Acceptance Tests
FRA	Finalisation Release Approval
FTA	Field Termination & Assembly
GVL	Grootvlei
HAZOP	Hazard And Operability Study
HMI	Human Machine Interface
HP	High Pressure
HVAC	Heating, Ventilation and Air Conditioning
IC	Initial Conditions
I/O	Input / Output
IP	Internet Protocol
KKS	Kraftwerk Kennzeichen System
KVM	Keyboard Video Mouse
LAN	Local Area Network
LCO	Local Control Operator
LOPP	Life of Plant Plan
LV	Low Voltage
NAS	Network Attached Storage
NTP	Network Time Protocol
OEM	Original Equipment Manufacturer
OPS	Operating Department
OT	Operational Technology
OTS	Operating Training Simulator

Abbreviation	Description
P&ID	Piping and Instrumentation Diagram
PC	Personal Computer
PCM	Process Control Manual
PDB	Power Distribution Board
PMIO	Process Manager Input Output
PP	Power Plant
PPE	Personal Protective Equipment
PS	Power Station
PTZ	Pan Zoom Tilt
RACI	Responsible, Accountable, Consult and Inform
RAID	Redundant Array of Independent Disks
RFT	Ready For Training
ROC	Required Operational Capability
RTS	Return To Service
SAT	Site Acceptance Tests
SCCC	Site Change Control Committee
SHE	Safety, Health & Environmental
SIT	Site Integration Test
SFPT	Steam Feed Pump Turbine
SRD	Stakeholders Requirements Definition
TCP/IP	Transmission Control Protocol/Internet Protocol
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
VAT	Verification Acceptance Test
VDSS	Vendor Document Submission Schedule
WTP	Water Treatment Plant

2.5 ROLES AND RESPONSIBILITIES

Grootvlei C&I Engineering: Compilation of this document.
Gx Engineering C&I: Support the review of this document.
Contractor: Responsible for execution and delivery of the contracted scope of Work.

2.6 PROCESS FOR MONITORING

The Primary process used for monitoring the application of the Technical Specification is the Design Review Procedure – this assures that the design achieves the requirements set out in this document. The Technical Specification will also need to be presented and approved by the SCCC.

Appendix J indicates the documentation requirements in terms of responsibilities of the *Contractor* and the *Employer*. This document will be updated and used as part of management of the project.

2.7 RELATED/SUPPORTING DOCUMENTS

[1] GVL/0216 Required Operational Capability: Design and Installation of New Operator Simulator.

[2] GVL/0583 Stakeholder Requirements Definition for the replacement of Operator training simulator

3. WORKS TO BE PERFORMED BY THE *CONTRACTOR*

3.1 EXECUTIVE OVERVIEW

The *Contractor* assesses, engineers and develops a detailed design, procures, manufactures, installs, tests, commissions, optimizes and hands-over the fully functional operator training simulator.

General

The objective of the *Employer* for the delivery of the simulator works is to follow a structured and well-documented approach in delivering a fully functional operator simulator. The baseline requirement is that all necessary components, including but not limited to infrastructure, mounting, and interconnections, shall be provided as part of the contractor's scope of work. This ensures a clear understanding of the full scope and prevents any ambiguity during the project execution.

The main systems for the operator simulator are broken down into 2 work packages or components or services required to complete the project. The bidders can either tender for one or both packages the components required to fully complete the project, however, the *Employer* reserve the right on the appointment of a bidder to each package /component or services in any combination it deems fit to manage its risk. The bidders are required to provide the detailed pricing for each work package or the combination of packages that they will be tendering for.

Technical Management: This function will be performed by Eskom personnel to oversee the entire project and will be involved in all development and execution phases of the simulator. Each scope will be executed with the involvement of an Eskom personnel. The 2 work packages are described below:

a) **Process modelling, simulator and Instructor software:**

- **Process modelling:** A *Contractor* to supply, develop, implement, test and optimise the process modelling for the process plant including the third-party systems (Boiler protection trip philosophy, turbine control and protection philosophy etc) as per section 3.10.2 of this document. The *Contractor*, together with the *Employer*, shall convert and configure all plant process flow diagrams, consistent data set as per the reference unit control and operating philosophies as per the works information, to simulate real-world conditions. The *Contractor* will also be responsible for the successful integration of their components to the rest of the solution or other components (HMI & DCS emulation/simulation).
- **Simulator and Instructor hardware & software:** A *Contractor* to supply, configure, setup, the simulator and instructor software, hardware, all other subsystems required for the complete functionality of

the operator simulator as well as the design and implementing the simulator network architecture to ensure the best performance conditions as per the works information. The *Contractor* will be responsible for the overall system integration as well as the lead for the commissioning of the entire simulator system. The *Contractor*, together with *Employer* shall, develop all test cases / scenarios, trainee evaluation and reporting to ensure a successful working solution. The system shall be capable of providing the standard industrial interface protocols (MODBUS, OPC, EtherNet/IP etc) in order for it to be interfaced with the components provided in package (b) below.

b) **Emulation of the Control System (DCS) and HMI:** A *Contractor* to supply, engineer, configure, setup, test and commission a dedicated hardware and software of the DCS and HMI emulation/simulation as per section 3.10.3 of this document. The DCS and HMI provided by the *Contractor* shall be designed with a similar look and feel, including behaviour characteristics as those of the reference unit. The *Contractor* will also form part of the commissioning for the simulator solution and shall ensure successful integration of their components to the rest of the solution. The system shall be capable of providing the standard industrial interface protocols (MODBUS, OPC, EtherNet/IP etc) in order for it to be interfaced with the components provided in package (a) above.

3.1.1 . Scope of Work

1) Engineering, design, procurement, manufacturing, factory acceptance testing, delivery, off-loading at site, storage, installation, testing, commissioning, optimizing, capability testing, decommissioning of existing hardware and as-built documentation for the complete Simulator replacement scope.
2) Replacement of obsolete systems and provision of new additional systems in order to comply with the *Employer's* standard 240-154243686 Technical Requirements for Power Plant Simulators Standard.
3) All plant arears controlled, displayed and alarmed from the reference unit's control system are included in the Simulator modelling scope.
4) The Simulator modelling scope includes all plant arears which are not controlled by the reference unit's main control system but which are controlled from 3rd party control systems (eg Turbine Control and Protection System) while still operated from the reference unit's operating desk.
5) All plant models are designed based on first principles to simulate plant operation from cold start-up to maximum, taking to consideration the effects of changing parameters such as pressure, flow and level and also the effects of these parameters due to starting and stopping of all plant auxiliary equipment. All models provide response of the same

magnitude and direction as the plant would give under and equivalent set of circumstances.

6) The design engineers engaged by the *Contractor* for this project must possess a comprehensive set of qualifications and expertise. At least one of the *Contractor's* design engineers should hold a degree or equivalent qualification in Computer, Electronic, Chemical Engineering. Additionally, they must demonstrate a deep understanding of relevant standards governing Fossil Fuel Power Plant Simulators. Experience and expertise in designing and implementing such systems are paramount, along with extensive process and Simulator knowledge/experience. While certification or registration with a recognized professional body such as the *Engineering Council* of *South Africa* (ECSA) is preferred, it is not mandatory. However, all design engineers must exhibit a strong commitment to ongoing professional development, ensuring they stay up to date with the latest advancements and best practices in the field.

7) The control system models are a complete duplication of the systems simulated including all controllers, mode selection, interlock and alarm functions. Control system models for motors, actuators, solenoids valves and similar devices simulated include all permissive, alarms outputs, interlocking and tripping functions. The scope of supply by the *Contractor* includes but not limited to the following:

   a. Trainee workstations
   b. Instructor workstation
   c. Engineering workstation
   d. Plant model workstation
   e. Video workstation
   f. Required equipment stands
   g. Emulation Server
   h. Simulation Server
   i. Application Server
   j. I/O Server
   k. Sound generator
   l. Essential Measurement Instrumentation screen
   m. Printers
   n. Network design and cabling
   o. Switches
   p. Time Synchronisation
   q. Cameras and microphones

r. Network attached storage (NAS) for the recording of audio, video system, backups for all computer equipment (e.g. Servers and workstations) and configuration data for non-computer equipment.

s. Latest software versions

t. Backups and disaster recovery procedures

u. Training

v. Provide the backups of the fully functional simulator system database (DCS/HMI emulation and plant model simulation) in two backup CD's or USBs as part of the handover process.

w. Simulator Documentation

The *Contractor's* scope further includes:

a. Removal and/or relocation of existing Simulator equipment shall be done according to the 240-56355731 Environmental Conditions for Process Control Equipment Used at Power Stations Standard, removal of furniture will be done by the Employer.

b. Cabling and racking

c. Power supply distribution and interfacing

d. Factory, site and acceptance testing and commissioning as per 240-154243686 Technical Requirements for Power Plant Simulators Standard.

e. Simulator codification and labelling of all equipment supplied as part of the works.

f. Earthing of all Simulator supplied equipment as part of the works.

g. All activities, services or equipment specified (special tools, consumables, etc).

h. All software, license and copyright agreements for the works.

3.1.2 Existing System / Present Situation

Grootvlei Power Station units are controlled using the Honeywell Experion DCS system. The station also has the Common Plant and EOD desks where the common plant and all the electrical systems are controlled from. In order for the Training departments to prepare up and coming new cadets, the station had an OTS installed. The installed OTS system consisted of two main parts; the Honeywell Experion R400.8 DCS system HMI part and UniSim Operation version R430.1 Build 316 – Patch 6 shadow plant part.

Originally, during RTS (2007) the station was making use of a generic training simulator to train and prepare plant controllers. This generic simulator was made up of panels with switches and nodes that the trainee could adjust to get certain simulated system response. This setup was very limited in terms of giving a response that is close to the actual simulated plant and the experience the trainees obtain was not enough for them to competently control the actual plant.

In 2010, the station procured the first computer-based OTS, Honeywell UniSim version SIMC200. The system could allow students to view the plant through the same HMI and graphics windows that they would normally see when they are running the actual plant. The system was commissioned and handed over to Eskom with certain defects. In addition, it was also realised that the system performance was not adequate according to the training department.

The above computer-based OTS system was then upgraded in 2014. However, the main objective of upgrading the system was only to improve the system response by only upgrading the hardware servers that the system was running on, thereby giving the student better experience when training on the system. In addition, the upgrade was also meant to resolve a limited number of defects supplied by the training department. After the system was commissioned and handed over to Eskom, it was also realised that there are still inherent design major defects on the system such that the training department was not able to effectively train the students since the system was not capable of running some of the major training scenarios and emergencies required by the operating department. These defects/technical issues did not allow the instructors to train students on all applicable/possible scenarios – all these issues are included in the appendix section *(Appendix A, Appendix B, Appendix C, Appendix D, Appendix E, Appendix F, Appendix G and Appendix H)*.

In an attempt to resolve some of the issues, the simulator was upgraded in 2014. This upgrade only covered the hardware computers that are running the system. Therefore, the model upgrade/shadow plant was not included and as a result most of the technical challenges were never resolved.

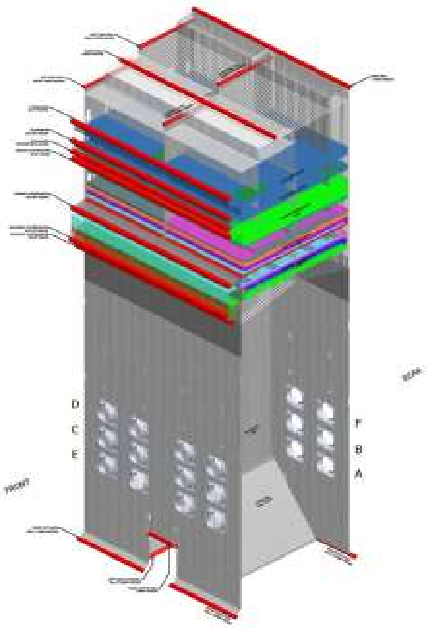
3.1.3 Main Functions

The project is aimed at delivering a simulator training solution that will be based on the following reference plant area:

1. Unit 1

The reference unit basic design information is provided below:

Units 1



Boiler	1 (200MW)
Manufacturer	Babcock & Wilcox
Type	PF fired Tower Boiler
Maximum continuous rating (MCR)	214.2 kg/s
Design Pressure	13.1 MPa
Final steam temperature	543°C
Final steam pressure	11.8 MPa
No. of burners	12-rear wall firing 12-front wall fired
Super heater type	Primary-horizontal Secondary-horizontal
Economiser type	Finned tube-two bank

The Simulator shall implement the most current operating philosophies, control philosophies and in accordance with all plant operating procedures. The Simulator is used primarily for the training of the *Employer's* operating staff.

In addition to the operator training, the Simulator is used to train the technical staff in detailed process response and control, to perform engineering analysis test prior to implementation of modifications on both the process and the control logic of the implemented control and instrumentation system.

The *Contractor* provides the Simulator that is capable of simulating the following as a minimum:

a. Complete plant start-up
b. Plant shutdowns
c. Load changes
d. Normal operating conditions
e. Abnormal operating conditions
f. Emergency conditions
g. Engineering analysis test and control logic testing

3.2 INFRASTRUCTURE PROVIDED BY THE *EMPLOYER*

3.2.1 Simulator Building

The *Employer* provides the rooms in which the Simulator equipment is located. The rooms are located at the Simulator building at Grootvlei Power Station main building. The following rooms are provided by the *Employer*:

a. Instructor room
b. Server room, currently in a soundproofed booth due to an excessive noise that was generated by the servers.
c. Trainee operator room

3.2.2 The Simulator room design

The *Employer's* existing Simulator room design consist of the following:

a. Floor tiling
b. Ceilings that suits the environment
c. Electrical plugs points
d. Electrical lighting
e. Wall finishes
f. Bottom access for cabling
g. Air conditioning and ventilation
h. The furniture

3.2.3 Trainee Control Room Desk Configuration

The *Employer's* desk configuration consists of the following:

a. Trainee Control Desk
b. Trainee operator chairs
c. Existing Flip system

3.2.4 Instructor room configuration

The instructor desk configuration consist of the following:

a. Instructor Desk
b. Chair/s
c. Printer table
d. Locker for the Instructor

3.2.5 Server Room

The server room configuration consists of the following:

a. Air-conditioning
b. Old server and switch cabinet(which is part of the works)

3.3 INFRASTRUCTURE PROVIDED BY *CONTRACTOR*

The *Contractor* provides the following:

a. Power requirements
b. Channelling of new cabling
c. Position of equipment and hardware
d. Equipment mounting
e. Any special isolation from electromagnetic interference
f. Any additional electrical plug point for new equipment
g. Provision of LAN connections and routing to each desk area where additional connections are required.
h. Any required equipment stands or table extension.
i. New layout drawings
j. Hardware required for the Simulator upgrade.
k. Assessment of the existing infrastructure (cabling, desk push buttons ect)

The final requirements and layouts of the desk and hardware is discussed and clarified during the unit Simulator system engineering phase (technical clarification meetings). The new layouts design by the *Contractor* for the Simulator room equipment is provided to the *Employer* for acceptance.

The *Contractor* is responsible for verifying and identifying all scope requirements for the Simulator as part of the *Contractor*s engineering and design effort in order to meet the functional and performance requirements of the works.

3.4 SIMULATOR METHODOLOGY

a. The project Execution Methodology describes the methodology to be adopted by the *Contractor* for executing the whole works.

b. The methodology required for the execution of the Simulator is described in the *Employer's* standard: 240-154243686 Technical Requirements for Power Plant Simulators Standard regarding the simulator replacement projects.

c. The *Contractor* undertakes all activities of engineering and design from basic engineering through technical clarifications, detailed engineering, system development, install and commissioning, acceptance testing, up to handover.

d. The *Contractor* is responsible for the supply of engineering deliverables in the form of documentation relevant to different activities as stated in the VDSS in Appendix J.

It is the responsibility of the *Contractor* throughout the execution of different contract activities to address the following and obtain the acceptance from a Project Manager:

a. Recommend any cost-effective proposals.
b. General assessment of the suitability of the information provided by the *Employer* to achieve the required performance standard.
c. Translation and incorporation of all mechanical, process and electrical documentation into the *Contractor*'s documentation format ensuring integrated documentation.

A fully integrated, high fidelity working Simulator is provided which meets the safety, reliability and operability criteria as detailed in the works.

3.5 SYSTEM ENGINEERING

a. During system engineering phase the *Contractor* performs the standard activities of system engineering as outlined in the sections of this works.
b. The *Contractor* may use the reference unit's data and the existing Simulator to collect data.
c. Collection and validation of data for the design of the Simulator is the responsibility of the *Contractor*.
d. The *Contractor* makes available at Grootvlei Power Station, on a full-time basis an engineer to co-ordinate the data collection and validation activities during the Simulator system engineering phase.
e. In the event that the *Contractor* determines that a void or conflict in the design data exist, the *Contractor* identifies such void or conflict and proposes alternate data, methods of filling the void or resolution of the conflict and submits the proposed solution to the *Employer* for acceptance.
f. The *Contractor* is responsible for validating and updating of all design data in the Simulator data register.
g. Design freeze for the Simulator is where the *Employer* accepts the final performance, functional, scope and equipment specifying documents for the unit Simulator and the *Contractor* is authorized to proceed with detailed engineering and design.
h. The *Contractor* submits documentation at design freeze for acceptance by the *Employer*. Documentation is submitted as per the VDSS Appendix J.

3.5.1 Technical Clarification

a. Technical clarification is where the *Contractor* undertakes the engineering and design activities to clarify with the Project Manager all technical issues to permit the *Contractor* to undertake the basic engineering phase.

b. All equipment having long delivery times is planned and technically clarified early in the technical clarification stage.

c. The technical clarification and design freeze activities are phased to suit the Accepted Program.

d. In the technical clarification, Project Manager reviews the updated performance, functional, and equipment specifying documentation and the *Contractor* prepares formal documentation for design freeze.

e. As the design and documentation is agreed between the *Contractor* and the Project Manager, it is formally signed off as accepted by the Project Manager.

f. Design freeze is where the Project Manager accepts the final performance, functional, and equipment specifying documentation as defined in Appendix J- VDSS and the *Contractor* is authorised to proceed with detailed engineering.

3.6 SIMULATOR DEVELOPMENT

The Simulator development is done at the vendor's premises, however, it's the *Employers* requirements that the simulator vendor involves the *Employers* engineers in the development of the simulator from the inception to implementation phase.

The Simulator developed by the *Contractor* is a replica of the reference unit.

The *Contractor* is responsible for the development of the high-fidelity and high realism simulators in terms of functionality, capability and behaviour as per the reference units design philosophy.

3.7 BASIC ENGINEERING

Basic Engineering is defined as being all activities to clearly identify the *Contractor*'s scope of work for the Simulator concerned.

As a minimum, Basic Engineering consists of the following activities:

a. High level engineering concepts- during which the rules, concepts followed in the various engineering and design activities are clearly defined, clarified and accepted.

b. Scope definition –during which detailed scope definition and clarifications are performed.

The Basic engineering activities are phased to suit the accepted Program.

All equipment having long delivery times are planned and technically clarified timeously during Basic Engineering to allow Detailed Engineering to commence in parallel.

The *Contractor i*s responsible to:

a. Identify any discrepancies that would lead to shortcomings in the design and making the *Employer* aware of such discrepancies.

b. Provide recommendations, where applicable, and take action to resolve such discrepancies.

c. Correct any discrepancies found in the design after Basic Design Freeze.

3.7.1 High Level Engineering concepts

As a minimum, the *Contractor* develops and clarifies the documents defined as being required for Basic Engineering in Appendix J VDSS.

3.7.2 Scope Definition

As a minimum, the *Contractor* develops and clarifies the documents as being required for Basic Engineering Design Freeze in Appendix J- VDSS for approval by the Project Manager.

As a minimum, the *Contractor* verifies and clarifies the following documents provided by the *Employer*:

a. Model parameters (plant heat balance, equipment performance curves and process flow diagrams etc)
b. Rooms and existing equipment
c. Existing plant drawings

3.8 DETAILED ENGINEERING

3.8.1 General Requirements

a. Detailed design is defined as being all activities required to translate the *Contractor*s scope of work, as defined at Basic Engineering design freeze, into fully functional system(s).
b. As a minimum, detailed engineering consists of the development, technical clarification and acceptance of the documents required for the Detailed Engineering design freeze as defined in Appendix J VDSS.
c. Detailed Engineering activities are conducted on the System Function Groups which will be defined by the *Contractor*, these are defined and detailed in the control and operating philosophies of the reference unit and will be provided by the Employer.
d. Detailed Engineering activities of the interfaces within the works and the interfaces to other systems, forms part of the works
e. The *Contractor* schedules a minimum of 2 design review meetings during this phase.
f. During the design review meeting the *Contractor* and *Employer* review progress to date and conduct detailed review and validation of the developed Simulator models.
g. The *Contractor* prepares a design report in preparation for each review meeting. The design reports are submitted to the *Employer* 14 working days prior to the relevant design review meeting.
h. The *Contractor* submits documentation as listed in the VDSS for acceptance by the *Employer*.

3.8.2 Procedure for submitting and acceptance of *Contractor*'s Design

The *Contractor* submits all documents according to the accepted VDSS. The process for submitting of documents is described below:

a. The *Contractor* submits the documents/drawings to the Project Manager.

b. The Project Manager register the documents.

c. The Project Manager will supply the documents/drawings to all relevant parties within the Project Manager's project team.

d. The Project Manager's team reviews the documents/drawings and will submit all comments or inputs to the Project Manager and the Project Manager submits to the *Contractor* for consideration.

e. If the Project Manager finds major deficiencies in the submitted documents/drawings the *Contractor* revises the documents/drawings and resubmits to the Project Manager.

f. The Project Manager reviews the document/drawings and if no major deficiencies are found, the *Contractor* organizes a Design Review session.

g. The Project Manager and the *Contractor* conduct a Design Review.

h. If any fundamental errors were found in the design or further actions are required, the *Contractor* records all concerns raised and revises the designs.

i. The *Contractor* organizes a Design Review session once all the designs were revised according to the concerns raised by the Project Manager.

j. If no fundamental errors were found in the design during the Design Review sessions, the *Contractor* compiles the Design Review minutes or report and submits to the Project Manager.

k. The Project Manager registers the report.

l. The Project Manager will accept the *Contractor*'s design once the report are accepted by the Project Manager's team.

3.8.3 Design Review Procedure

The *Contractor*'s is the Design Authority as defined in the Design Review Procedure (240-53113685).

The *Contractor* submits all the simulator designs to be reviewed by the *Employer*, the *Contractor* revises/updates the designs as per the feedback from the *Employers* representatives before proceeding to the next phase.

3.8.4 Project Engineering Change Procedure

The *Contractor* takes note of the *Employer*'s Project Engineering Change Procedure (240-531144026). An engineering change includes any proposed change originating from *Contractor's* engineering, project management or construction management.

The Project Engineering Change Procedure applies to the *Employer*'s personnel or *Contractor*s performing engineering or engineering related work where the quality of the engineering work performed is the direct responsibility of the Project Manager.

3.8.5 Configuration Management

Contractor ensures that all simulator labelling comply with the requirements of the approved Eskom labelling specification and in line with Eskom configuration management requirements.

3.9 SYSTEM INTEGRATION

The *Contractor's* works include test and verification of individual software and hardware components of the design specification as agreed upon at Design Freeze as well as integration of all hardware and software of the works.

The *Contractor* integrates all the works including the 3rd party systems.

The *Contractor* is responsible for the integration of the plant model, emulation system and the process automation system application software.

3.10 REQUIREMENTS

3.10.1 General Requirements

a. The *Contractor's* plant investigation, installation and commissioning are done at site, Grootvlei Power Station, and the basic engineering is done in South Africa.

b. The *Contractor* provides all material, equipment and services necessary for the obsolete Simulator hardware and software replacement scope.

c. The *Contractor* includes all equipment, devices and services which are not specifically mentioned within this Works Information document, but are necessary for the completeness of the design, equipment and systems, meeting the functional intent and requirements of the works.

d. The solution is consistent with modern power plant best practices, and is in compliance with all applicable standards, guidelines and statutory regulations and functional safety requirements.

e. For the duration of the works, the *Contractor* provides specialist expertise, in accordance with the activities during the various project phases for:

   i. The upgrade that will be undertaken as part of the works

   ii. Identifying the commissioning strategy, planning and execution on the Simulator. The specialist and resources do not change during that specific phase for the sake of continuity unless required by the Project Manager.

f. The plant responses as simulated by the Simulator are identical in time and response to the actual reference plant time and responses under similar conditions. Operator training is thus performed in an environment that is identical to that of the reference plant.

g. All critical functions, major plant components and auxiliaries that directly affect the primary operation of the plant, are modelled with high fidelity to provide a high degree of realism to the operator.

h. The entire Simulator is provided in accordance with 240-154243686 Technical Requirements for Power Plant Simulators Standard and 240-158191826 Generation Operation Training Requirements Specification for power plant Simulator.

i. The Simulator is provided with functionality as described in the standard ANSI/ISA-77.20-2012 Fossil Fuel Power Plant Simulators Functional Requirements.

j. The *Contractor* submits the model simulation fidelity requirements for total simulation to the *Employer* for acceptance prior to design freeze.

k. The Simulator design allows for expansion and future modifications.

3.10.2 Plant Model

The plant model is defined as the physical model of the plant (contains models of the plant equipment (level, temperature, flow etc.) and equipment behavior.

The *Contractor* provides an integrated industry standard development software package. The front end of the development software package for plant models and C&I employ object orientated functionality making it user friendly to Operating, Maintenance and Engineering personnel in the long term, without the need for manual intervention and or/specialist Simulator engineering skills.
The plant models simulate the actual mechanical plant, based on first principles, accurately simulating operational parameters for all components of the plant/process.
Plant model shall comply with Section 3.2.3 and Section 3.2.1.5 of 240-154243686 Technical Requirements for Power Plant Simulators Standard.

3.10.3 Emulator (DCS)

The emulator consists of the control system emulator including the HMI. The *Contractor* implements the emulator using proven industrial technology in order to maintain the highest possible fidelity and realism, and to facilitate the maintenance and updating of the simulator's control system relative to the reference unit.

The *Contractor* provides control system emulation that complies with Section 3.2.2.9 to 12 of 240-154243686 Technical Requirements for Power Plant Simulators Standard.

3.10.4 Engineering workstation

The *Contractor* provides as part of the works a complete engineering facility equivalent to the Engineering workstation on the reference unit for the Simulator. The engineering facility for the Simulator allows the *Employer* to perform engineering, maintenance and/or development on all the Simulator subsystems and programs.

The Simulator engineering facility is integrated as part of the Simulator and comply with the requirements in Section 3.2.1.4 of 240-154243686 Technical Requirements for Power Plant Simulators Standard.

3.10.5 Instructor workstation

Instructor station defined as the interface point between the instructor and the simulation software. Through this workstation, the instructor controls the simulation process, initiates functions, malfunctions, and manipulates plant model variables. The *Contractor* provides an Instructor workstation that complies with the requirements described in section 3.2.1.5 of 240-154243686 Technical Requirements for Power Plant Simulators Standard.

3.11 SIMULATOR FUNCTIONAL REQUIREMENTS

a. The *Contractor* engineers a high-fidelity Simulator.
b. The Operator training Simulator is provided with functionality described in the standard: ANSI/ISA-77.20-01-2012 Fossil Fuel Power Plant Simulators Functional Requirements.
c. The Simulator shall be a replica of the reference unit.
d. The Simulator complies with the functional requirements described in Section 3.1 of 240-154243686 Technical Requirements for Power Plant Simulators Standard.

3.11.1 Simulator Non-Functional Requirements

The Simulator non-functional requirements provided by the *Contractor* shall comply with the requirements in section 3.2 of 240-154243686 Technical Requirements for Power Plant Simulators Standard and 240-158191826 Generation Operation Training Requirements Specification for power plant Simulator.

3.12 SIMULATOR PERFORMANCE REQUIREMENTS

The Simulator provided by the *Contractor* shall be capable of simulating the following systems:

a. All systems controlled, displayed and alarmed from the control room’s reference unit.
b. Capability to simulate modified plant designs, different process scenarios and plant conditions.

The Simulator performance criteria complies with ANS/ISA-77.20-2012 Fossil Fuel Power Plant Simulators Functional Requirements.

3.13 SIMULATOR HARDWARE

3.13.1 General Requirements

The *Contractor* provides all hardware necessary to fulfil the works.

The Simulator hardware complies with the requirements in Section 3.2.1 of 240-154243686 Technical Requirements for Power Plant Simulators Standard and Section 3.1 of 240-158191826 of Generation Operation Training Requirements Specification for Power Plant Simulator.

As a minimum, the *Contractor* provides the following hardware equipment but not limited to:

a. Trainee workstation
b. Engineering workstation
c. Instructor workstation
d. Plant model workstation
e. Simulator servers
f. Emulation server
g. Application server
h. Sound generator
i. Essential Instrument screen
j. Printers
k. Network and network switches
l. Time synchronisation hardware
m. Cameras and microphones
n. Network attached storage

The *Contractor* shall perform an assessment on the existing server cabinet, switch cabinet, trainee desk push buttons and verifies if they can be reused, and if equipment is deemed functional and in good working order, the *Contractor* will incorporate this equipment in his works.
Operator interface (servers, PCs, workstations, VDU based systems, network and communication systems) shall be supported for 6 years.

3.13.2 Servers

The minimum specification for control server hosting operating, engineering, supervisory applications and plant information as well as the operating and engineering database are as follows:

a. Redundant CPU
b. Hot swappable redundant power supplies
c. 19” Rack mounted
d. Redundant case fans

Power supply distribution to servers is the responsibility of the *Contractor.*

Unauthorised access is denied on all servers.

3.13.3 Switches

a. The network switch shall be compatible with the operating system.
b. Switches are located in a network cabinet, shall be of industrial Ethernet type and suitable for an uncontrolled & harsh environment conditions.
c. Unused ports are blocked via network management system and can be activated when required.
d. Any software required when replacing the switch is supplied as part of the works together with the procedure to configure a switch.

3.13.4 Workstations

The Simulator workstations complies with the requirements in Section 3.2.1 of 240-154243686 Technical Requirements for Power Plant Simulators Standard and 240-158191826 Generation Operation Training Requirements Specification for power plant Simulator. Trainee and the engineering workstation quantity, type, specification, configuration, peripherals and layout shall be a replica to that of the reference unit.

3.13.5 HMI

The HMI application software and its functionality (graphics, alarms, faceplates, trends, process tags, etc) shall be identical to the reference unit.

3.13.6 Printers

The Simulator shall be equipped with two colour laser printers, printers are provided at Trainee control room and Instructor room for logs, reports, hard copies and other documents on request by operators, engineers and maintenance personnel.

As a minimum, all printers provided by the *Contractor* are laser printers with A3 and A4 printing capabilities.

3.13.7 Printer Stands

a. The *Contractor* provides a suitable table or stands for the Trainee control room printer, the printer stand subjects to acceptance by the *Project Manager*.
b. The Instructor room printer shall use the existing table. All systems should be connected to all printers provided.
c. The *Contractor* decommissions all old printers and hands them over to the *Employer*.

3.13.8 Network attached storage

The *Contractor* shall provide a network attached storage (NAS) device for the backing-up and restoration of the simulator system and data (modelling, emulation and simulation software).

The backup system creates and maintains backups for all computer equipment (e.g. Servers and workstations) and configuration data for non-computer equipment (e.g. network devices such as switches and routers) and shall be in accordance with the requirements in section 3.2.1.20 and 3.2.11.1 of 240-154243686 Technical Requirements for Power Plant Simulators Standard.

3.14 SIMULATOR SOFTWARE REQUIREMENTS

The *Contractor* provides the Simulator software in accordance with the requirements in Section 3.2.2 of 240-154243686 Technical Requirements for Power Plant Simulators Standard and Section 3.2 of 240-158191826 Generation Operation Training Requirements Specification for Power Plant Simulator.

All software patches, bug fixes, and software upgrades for the systems are provided throughout the duration of the works.

Upgrades are undertaken to correct any deficiencies, defects and bugs found with the installed software.

The Simulator software shall include, as a minimum, the following software programs:

a. Software plant models, which simulate continuously in real time the behaviour of the simulated reference plant(s) systems over the entire range of normal, abnormal, and emergency conditions.
b. Functional fidelity of the Simulator should be based on the reference unit.
c. Instructor station software, which provides the instructor with the necessary Simulator control and trainee monitoring functions.
d. Development and maintenance software necessary to update the plant models.
e. Computer operating systems and utility software.
f. All software, license and copyright agreements for the works.

3.15 USER MANAGEMENT

The *Contractor* provides the system with the user management for the Simulator to manage all users, user rights and user authentication.

The functionality provided by the user management system includes-but not limited to the following:

a. Issuing and monitoring authorizations i.e. user administrator
b. Logging all permissible connections and manually reporting thereof
c. Access security

d. Management of user's rights across all software packages such that it is possible for each user to have a user-defined username and password to access the different software packages.
e. Configuration of each user's access rights or access level across the different software packages.

Passwords can be changed at regular intervals.

3.16 EXTERNAL ENVIRONMENTAL REQUIREMENTS

3.16.1 Network Cabinets

The following types of equipment are in a network cabinet unless specified otherwise or elsewhere in this document:

a. Servers
b. Switches
c. Workstations
d. Automation network equipment
e. Power Distribution Units (PDU's)

3.16.2 Network Cabinet Physical Characteristics

Each network cabinet has the following characteristics:

a. Front and rear access
b. Network cables and power cables shall be separated (not use the same rack at entry)
c. The cabinets doors shall be lockable.
d. The design of the cabinet ensures that the air flow is managed correctly.
e. Internal cable management systems are used for both horizontal and vertical cable management.
f. Intelligent rack mounted power distribution units (PDUs) are used.
g. A single rack mounted LCD & Keyboard per network cabinet for access to all servers and workstations contained in the cabinet concerned.
h. The total equipment heat load in each cabinet is provided.
i. The cabinets are designed such that there is no liquid ingress from the cabinet cooling system to equipment contained.

3.17 NETWORK CABLING

a. Network cabling is defined as being all cabling forming part of the automation network.

b. Network cabling and associated infrastructure are provided as part of this project and shall be provided by the *Contractor*.
c. The scope includes design, supply, installation, termination, labelling, testing, and commissioning.
d. Where new routes for network cabling and any power supply cabling are required, these are of a consistent and integrated design that takes into account cabling and racking routes for common modes of failure and the redundancy that is required in order to prevent a single point of failure.

3.17.1 Cable Schedules

a. Accurate records are kept in Cable Schedules for all cabling.
b. The cable schedules are provided inclusive of origin, location, details, revision, target, type, size and termination details.
c. Termination schedules are to be provided for all cables.
d. All network cabling that is required to be routed separately from each other is defined.
e. A cable stock schedule is kept up to record all cables delivered to and removed from site.
f. The *Contractor* provides a cable management system for duration of the works for acceptance by the Project Manager.

3.18 POWER SUPPLY AND DISTRIBUTION

Contractor is fully responsible for Simulator power distribution design, cabling and commissioning to all C&I equipment. The power supply distribution design complies with 240-56227443 Requirements for Control and Power Cables for Power Station.

3.19 INTERFACE REQUIREMENTS

The following has been identified as interfaces:

3.19.1 Other Operator/Trainee interfaces

The *Contractor* design ensures that the Simulator HMI emulator presents the same interfaces as the reference unit at Grootvlei Power Station. Such interfaces include but not limited to:

a. Turbine Control and protection system
b. Electrical systems (AVR, Metering, Gen protection, etc.)
c. Dust handling plant
d. Bottom ash
e. Emissions monitoring and control
f. Outside plant indications
g. Fabric filter plant Interface
h. Boiler tube leak detection system
i. Burner Management System

3.19.2 Security interfaces:

Where external interfaces are identified during detail design, the *Contractor* shall comply with 559-577223024 Generation Cyber Security Standard for Operational Technology and 240-56355910 Management of Plant Software Standard for meeting this requirement in the design. All external interfaces are required to pass through a DMZ using firewalls to prevent unauthorised access to Simulator system.

3.19.3 Electrical Interfaces

Where Electrical interfaces are required during detail design, the *Contractor* shall comply with Eskom standard 240-56227443 Requirements for Control and Power Cables for Power Stations Standard.

3.20 GENERAL DESIGN AND MANUFACTURING PROCESS

a. The *Contractor's* responsibilities includes the following:
b. The *Contractor* complies with the quality requirements as per QM-58: Supplier Contract Quality Requirements Specification
c. Standardise equipment used by utilising existing methods of operation with existing type of components ensuring spares availability at Grootvlei Power Station.
d. Detailed drawings for construction. Drawings are also submitted in CAD formats.
e. The *Contractor* provide calculations, new and updated drawings, test reports, manuals, data sheets and documentation for each sub-system.
f. Adhere to Grootvlei Power Station labelling system for plant identification (issuing of AKZ numbers).
g. All equipment provided by the *Contractor* is comprehensively factory tested prior to shipment.

3.21 TESTING REQUIREMENTS

As a minimum, the *Contractor* performs the Acceptance Tests as detailed in Appendix B of 240-154243686 Technical Requirement for Power Plant Simulators Standard.

The Simulator system shall be subject to numerous Acceptance Tests over the period of development. All Simulator Acceptance Tests shall comply with IEC 62381, ANSI/ISA77.20.01-2012, as well as requirements stated herein.

As a minimum, the vendor conducts the following Acceptance Tests at the end of each respective phase of the Simulator development:

a. Simulator Site Acceptance Test (SAT)
b. Simulator Pre-Factory Acceptance Test (pre-FAT)
c. Simulator Factory Acceptance Test (FAT)
d. Simulator Site Integration Test (SIT)
e. Simulator "As-built" Acceptance Test (ABAT)

f. Simulator Verification Acceptance Test (VAT)

3.22 EQUIPMENT AND MATERIAL

The *Contractor* provides an inventory listing of all equipment to be shipped to site. The Project Manager verifies and accepts this inventory list prior to packaging and shipping.

3.23 PACKAGING, HANDLING AND TRANSPORTING REQUIREMENTS

All equipment that will be used must be packaged such that it can be easily transported without being damaged. This is inclusive of computer screens, workstations and servers.

The equipment that needs to be removed will be clearly marked before decommissioning starts by the *Contractor*. Equipment not marked for re-use must be removed and handed over to the Project Manager if still functional or transported to the dedicated disposal areas.

3.24 CONSTRUCTION ON SITE

a. The works forming part of commissioning and testing is not embarked on until the Project Manager's acceptance has been obtained for construction and erection work performed in this stage.

b. The minimum documentation required for the installation and commissioning stages is defined in the VDSS.

c. The stage consists of procurement, installation and onsite inspection and testing of all supplied items forming part of the scope. 2 hard copies and 2 soft copies of detailed production engineering and construction package documentation are prepared and issued by the *Contractor* to the *Employer* for acceptance.

d. These documents are issued for design review 14 days prior construction commencement and by the dates shown in the program.

e. Testing of supplied and existing equipment is required by the *Employer*, these tests are carried out by the *Contractor* after erection to prove compliance to the *Employer*'s standards and works.

f. The erection and installation is considered complete once the quality inspections and test for the installation concerned have been accepted by the *Employer*.

g. The *Employer* reserves the right to appoint representatives to inspect all parts during erection or after and to be present at any of the test specified. The *Employer* is free to specify hold points and witness points during installation and testing stages of the project.

h. The *Contractor* gives advance notice to the *Employer* of hold and witness points (six weeks for international vendor and 21 days for local vendor.

i. The *Contractor* provides all test equipment and tools required for testing.

j. Assessment of existing cable racks and provision of all new racking requirements where necessary is the responsibility of the *Contractor*. The cabling layout and design shall be subject to the *Employer*'s approval.

3.25 DESIGN CRITERIA

The simulator provided by the *Contractor* shall be capable of simulating in real time the normal operating conditions of all the applicable reference plants. The simulator shall be delivered as full scope, high realism simulators based on a specific reference plant.

3.25.1 Simulator Capabilities

The following function groups shall form integral part of the Unit 1 reference plant and they must be modeled as such by the *Contractor*:

Unit 1 applicable function group

FUNCTION GROUP	PLANT
FG01	BOILER PROTECTION SYSTEM
FG02	UNIT COORDINATOR
FG03	FUEL OIL AND GAS
FG04	MILLS A, B, C, D, E, F
FG05	DRAUGHTS GROUP
FG06	SOOT BLOWER
FG07	STEAM GENERATION
FG08	UNIT AUXILLARY COOLING
FG09	CONDENSATE
FG10	FEED WATER
FG11	TURBINE DRAINS
FG12	TURBINE CONTROL AND PROTECTION SYSTEM
FG13	TURBINE AUXILLARIES
FG14	GENERATOR
FG15	PRECIPITATOR AND FABRIC FILTER PLANT
FG16	UNIT ELECTRICAL RETICULATION
FG16	UNIT ELECTRICAL RETICULATION
	SYSTEM ARCHITECTURE

3.25.1.1 Normal Operation

The Simulator provided by the *Contractor* shall be capable of simulating in real time, operating conditions as per the applicable reference plant.

The Simulator provided by the *Contractor* shall calculate plant system parameters that correspond to particular operating conditions, displaying these parameters on the appropriate instrumentation and simulator HMI's, and shall provide proper alarm or protective system actions, or both.

The minimum operations that the simulator provided by the *Contractor* shall be capable of performing, using only operator action that is normal to the reference plant(s), are as follows:

3.25.1.2 Plant Start-up

a. Start-up from cold to 100% load. (Starting conditions must be cold shutdown conditions of temperature, and pressure for all systems)

b. Start-up from warm standby to 100% load.

c. Start-up from hot standby to 100% load.

d. Boiler, Turbine, Unit Trip followed by recovery to rated load.

3.25.1.3 Shutdown

a. Shutdown from 100% load to hot standby conditions
b. Shutdown from 100% load to hot standby and cool-down to cold shutdown conditions

3.25.1.4 Steady Load

a. Steady load at Max Load (EL1)
b. Steady load at full load (MCR)
c. Steady load at incremental mill load limits. (1 Mill, 2 Mill, 3 Mill etc. Operation)
d. Steady load at minimum load without oil support. (60% MCR/ 120 MW)

3.25.1.5 Load Variance

a. Boiler start-up to match required steam conditions for turbine run-up.
b. Turbine start-up and generator synchronization.
c. Generator load to increase according to reference plant load requirements after synchronization.
d. From 0 MW unit must be loaded to full automatic control as per the reference plant requirements.
e. First mill in operation to full load
f. Steady full load operation and decrease load to 0 MW.
g. Steady load at 50% with one draught group in service, increase load to 100%. During this condition all plant temperature and other parameters should respond according to how the actual unit/plant would respond.
h. Steady load at 100%, shut down or tripping one draught group and reduce load to 50%

i. Steady load at 50% with one electrical feed pump in service, increase load to 100%
j. Steady load at 100%, shut down or tripping one electrical feed pump and reduce load to 50%
k. Mill changes up and shutdown.
l. On load testing of equipment, with the unit/plant running.
   l.1. turbine valves
   l.2. pyro's
   l.3. AC lub oil pumps
   l.4. DC lub oil pumps
   l.5. Auxiliary plant change overs

3.25.2 Capability Tests (As Applicable to Reference Plant)

a. All capability tests shall be done by the appointed site Operating representative in the presence of the Simulator OEM representative, the relevant appointed site system engineers and the project Manager.

b. Capability tests passed by the reference Unit must be passed on the simulator as well. Where capability tests failed or was not performed on the reference Unit, the Simulator should still be tested for records purposes, but it is not required to pass.

c. The relevant site shall provide a data set of approved critical and non-critical parameters as per heat balance, against which the simulator performance and accuracy shall be tested.

d. All test results shall be captured and compared to the approved data set from the relevant site and shall be within the approved acceptable steady state of critical parameter range.

e. No capability acceptance test shall be signed off unless all parameters on the simulator as per approved data set is within the specified and approved critical parameters range.

f. Capability Tests shall include but not be limited to the following:

a) Unit Start-Up

- Cold Start
- Warm Start
- Hot Start
- Miss match in steam temperatures to cause stress or diff expansions on turbine during
- light up conditions (to match unit conditions)

b) Load Increase

- EL 1 capability of the Unit
- Load increase from 40% to 60% as per reference plant designed loading rate
- Load increase from 50% to 75%TMCR as per reference plant designed loading rate

- Load increase from 75% to 100%TMCR as per reference plant designed loading rate

c) Load decrease

- From 100% to 75%
- From 75% to 50%
- From 60% to 40%

d) Load runback

- ID Fan Runback
- FD Fan Runback
- PA Fan Runback

- Unit Mill Runback - designed number of mills in service for 100% MCR (Trip top mill)
- Unit Mill Runback - designed number of mills in service for 100% MCR (Trip bottom mill)
- Unit Mill Runback - designed number of mills in service for 100% MCR (Trip centre mill)
- Unit Mill Runback - designed number of mills in service for 100% MCR (Trip two Mills)
- HP Heater "Load Limiting Runback" (Trip/bypassing of one HP Heater Bank)
- Vacuum De-loading
- Pressure de-loading

e) High and low Frequency response tests at different frequencies, according to site design specifications and in line with the requirements set in the Engineering Standard.

f) Load decrease request:

- 100% loading down to 40% loading at plant design loading rate – 45 minutes stabilisation.
- 40% loading up to 100% loading at plant design loading rate – 45 minutes stabilisation. time at 100%.
- 40% to 100% loading at plant design loading rate and immediate ramp down once 100% loading achieved to 40% loading.
- 1 hour stabilisation check at 40%.

g) Boiler:

- 100% MCR – Electrical Feedwater pumps on load – electrical Feedwater pump capability – 50% Feedwater pump capability. (Where applicable)
- 100% MCR with SFP on load – SFP capability/runback – electrical Feedwater pumps cut-in
- 100% MCR with SFP on load – SFP capability/runback – 50% electrical Feedwater pumps cut-in.
- Feedwater regulating valves change-over.
- Condensate Extraction Pump (CEP) trip with standby at 100% TMCR load
- Pyrometer testing

h) Turbine

- Control oil pump change-over
- Jacking oil pump change-over
- Stator cooling water pump change-over
- Generator seal oil pump- change over
- Governor valve step tests
- Valve gear exercise tests (full load)
- Cooling water pumps change over
- Turbine over speed trip testing
- Vacuum decay testing
- Unit demineralised water consumption test

i) Generator

- Over excitation limiter functionality
- Max Field Current Limiter functionality test
- Under Excitation Limiter functionality test
- Minimum Field Current Limiter functionality test
- Stator Current Limiter functionality test
- V/Hz Limiter functionality test
- Leading capability test
- Lagging capability test
- Stator earth fault testing

- Rotor earth fault testing

j) All Unit capability tests as per Unit capability acceptance testing procedure and approved criteria.

All tests to be in line with the plant response – detailed plant parameters for the various tests to be available and the Simulator performance test results to be in line with the critical parameters responses/measurements as per the test procedure.

3.25.3 Plant Malfunctions

The simulator provided by the *Contractor* shall be capable of simulating abnormal and transient conditions in real time, including malfunctions and equipment failure to demonstrate inherent plant response and automatic plant control functions.

It shall be possible to:

- Conveniently insert and monitor remote plant functions, external parameters and malfunctions through instructor action or pre-programming.
- Insert multiple malfunctions at the same time and also have the ability to create and execute macro functions where several grouped malfunctions can be inserted with one action.
- Link the Alarm Response Procedure (ARP) for each of the malfunction conditions possible for a specific reference plant within the simulator, to allow instructor and trainee to call up the ARP for reference purposes.

Apart from all the standard malfunctions the following must be included.

- Individual LV Boards failing
- Individual 6.6kV Boards failing
- Individual 3.3kV Boards failing
- Individual 11kV Boards failing
- 275/400kv HV Yard breaker failing

3.25.3.1 Generic Malfunctions

Generic Mulfunctions

COMPONENT	MALFUNCTION DESCRIPTION
Motor Operated Valve/Damper	Fail Open/Close/As is/ Specified value
Solenoid Operated Valve/Damper	Fail Open/Close/As Is
Air Operated Valve/Damper	Fail Open/Close/As is/ Specified value

Mechanically operated safety, bypass & leak-off valves	Fail Open/Close/As is/ Specified value
Pump/Fan/Motor	Trip / Fail to Trip / Fail to Start after Trip
Breaker	Trip / Fail to Trip / Fail to Start after Trip
Breaker	Fail To Close After Trip
Transmitter	Fail to Low / high /given limit
Transmitter	Increase Noise
Valve/Actuator/Motor Breaker/Damper/Solenoid	When any item is switched to local on the plant, there must a “local” indication on the HMI
Valve/Actuator/Motor Breaker/Damper/Solenoid	Switchgear or electrical fault must be indicated on HMI

3.25.3.2 Specific Malfunctions

Specific Malfuntions

PLANT	SPECIFIC MALFUNCTION	RANGE
Condensate	1. Circulating Water Leak In Water Box	Variable
	2. Condenser Tube Leak	Variable
	3. Loss Of Condenser Vacuum (Air In-Leakage)	Variable
	4. Dirty Tube Sheet	Variable
	5. Condenser Level Control Valve Fails To Operate	Variable
	6. Gland Steam Pressure Low	Variable
	7. Deaerator Safety Valve Fault	Discrete
	8. Circulating Water Leak In Water Box	Variable
Feedwater	1. SFPT Vibration	Variable
	2. SFPT High Bearing Temperature	Variable
	3. SFPT Low Injection Water Pressure	Variable
	4. FW Heater Leak	Variable
	5. FW Oscillation	Variable
	6. Feedwater Regulating Valve Control Fails	Variable

PLANT	SPECIFIC MALFUNCTION	RANGE
	7. EFP Trip	Discrete
	8. EFP Automatic Start Fails	Discrete
	9. EFP Leak Off Valves Fail	Discrete
	10. Microwire filter blockage	Variable
Boiler	1. Spurious Boiler Trip	Discrete
	2. Boiler Drum/Collecting vessel control failure	Variable
	3. Boiler Pyrometer Protection Operates	Discrete
	4. Loss Of Boiler Ash Hopper Seal /Air ingress into furnace	Variable
	5. Economizer tube leak	Variable
	6. Waterwall tube Leak	Variable
	7. Superheater tube leak on different sides and areas of the superheater	Variable
	8. Waterwall Slagging/fouling	Variable
	9. Superheater Slagging/fouling (On each individual SH – different sides)	Variable
	10. Attemperator/ De-Superheater Spray Water Valve Fails	Variable
	11. Spurious opening of safety valves	Variable
	12. High or low furnace pressure	Variable
	13. Oil burner flame failure	Discrete
Draught Group	1. Furnace Pressure Oscillation	Variable
	2. Air Heater Bearing Failure	Variable
	3. Air Heater High Differential Pressure (Dirty)	Variable
	4. Air Heater Air-To-Gas Leakage	Variable
	5. Air Heater Trip	Discrete
	6. Air Heater Fire	Variable
	7. FFP fire	Variable
	8. Low/High oxygen	Variable
	9. High/Low CO	Variable
	10. FD/ID Fan Trip	Discrete
	11. FD/ ID /PA Fan Vanes Stuck In Selected Position	Variable

PLANT	SPECIFIC MALFUNCTION	RANGE
	12. FD/ ID /PA Fan Bearing Temperature High	Variable
	13. FD/ ID /PA Fan Motor Bearing Temperature High	Variable
	14. LH or RH FFP blockage	Variable
	15. Air heater soot blower stuck	Discrete
	16. Dew point on gas air heater	Variable
	17. Air heater stationary	Discrete
	18. FD/ ID Fan oil pump fail	Variable
	19. FFP gas inlet temperature high	Variable
	20. FD/ ID /PA Fan lube oil pressure low	Variable
Mills	1. Mill Lube Oil Pressure Low	Variable
	2. Mill Fire	Variable
	3. Mill Feeder Trip	Discrete
	4. Mill Trip	Discrete
	5. Mill Running Out Of Coal (Mill outlet temperature high)	Variable
	6. Mill Chokes (mill differential pressure high)	Variable
	7. Mill gearbox lube oil Temperature high	Variable
	8. Wet Coal To Mill (Mill outlet temperature low)	Variable
	9. PF Pipe Blockage	Variable
	10. Low PA flow	Variable
	11. Low seal air pressure	Variable
	12. Mill feeder over/under speed	Variable
Fuel Oil	1. Oil Burner Flame Failure	Discrete
	2. Propane gas pressure low	Variable
	3. Fuel Oil Pump Trip	Discrete
	4. Burner control air pressure low	Variable
	5. Main Propane Gas Isolating Valve closed	Discrete
	6. Fuel Oil Pressure Low	Variable
	7. Fuel Oil Temperature Low/high	Variable
	8. Core air failure	Discrete

PLANT	SPECIFIC MALFUNCTION	RANGE
HP & LP Heaters	1. HP Heater Level Control Valves Fails	Variable
	2. HP Heater Tube Leak	Variable
	3. LP Heater Level Control Valves Fails	Variable
	4. LP Heater Tube Leak	Variable
	5. HP heater out of service	Variable
	6. LP heater out of service	Variable
Main Turbine	1. Turbine Water Induction	Variable
	2. Lube Oil cooler oil Leak	Variable
	3. Turbine Lube Oil Pressure Low	Variable
	4. Turbine Lube Oil Temperature High	Variable
	5. Turbine Bearing Temperature High	Variable
	6. Diff Expansions High or Low	Variable
	7. Shaft Position Positive or Negative	
	8. Turbine Bearing Vibration High	Variable
	9. Full Arc/Partial Arc Transfer Failure	Variable
	10. Gland steam pressure low	Variable
	11. One and/or multiple Governor or Emergency Stop valves failing close/open	Variable
	12. Turbine gland steam temp malfunction	Variable
	13. HP turbine wet steam	Variable
	14. Turbine exhaust steam temperature high	Variable
	15. Control oil pressure low	Variable
Generator	1. AVR Failure / Loss of excitation	Discrete
	2. AVR Trip To Manual	Discrete
	3. AVR Instability	Variable
	4. Stator Cooling Water Conductivity High	Variable
	5. Seal Oil/H2 Gas Diff Pressure low/high	Variable
	6. Protective Relay Action (Differential, Ground, Etc)	Discrete
	7. Seal Oil Filter Blocked	Variable

PLANT	SPECIFIC MALFUNCTION	RANGE
	8. Unit Islanding	Discrete
	9. H2 Gas Temperature High	Variable
	10. H2 Pressure Low	Variable
	11. Main Generator Trip	Discrete
	12. Reverse power trip	Discrete
	13. Gen fail to synchronise	Discrete
	14. Stator coolant flow low	Variable
	15. Generator bearing temperatures high	Variable
	16. Generator bearing vibrations high	Variable
Electrical	1. Main Transformer Loss Of Cooling	Variable
	2. Station Service Transformer Loss Of Cooling	Variable
	3. Unit Transformer Winding Temperature High	Variable
	4. Loss Of 380VAC Diesel Generator Board	Discrete
	5. Loss Of essential Board	Discrete
	6. Loss Of HV individual unit board	Discrete
	7. Loss of LV unit board individual boards	Discrete
Unit Controls	1. Mill Sequential Trip Fail	Discrete
	2. Feedwater Control Fail	Discrete
	3. Fuel Master Fail	Discrete
	4. Capability Fail	Discrete
	5. Condensate System SGC Fail	Discrete
	6. Superheater Temperature Control Setpoint Fail	Discrete
	7. Mill SGC Fail	Discrete
	8. EFP SGC Fail	Discrete
	9. Oil Burner SGC Fail	Discrete
	10. Vacuum Raising SGC Fail	Discrete
	11. Feeder Speed Transducer Fail	Discrete
	12. Draught Group SGC Fail	Discrete

3.25.3.3 Remote malfunctions

Control and operating functions that are performed outside the control room or provide some input to the simulation models and are necessary to perform the reference plant's normal and abnormal operations shall be simulated.

Remote malfunctions

REMOTE MALFUNCTIONS		RANGE
1.	Breakers on all unit plant (in/out)	Racked in/out/earth applied/open/close
2.	Field operated devices (Manual/throttling/isolating valves and bypass valves, drains, filter change over etc.	On/Off; open/close; variable
3.	All vents	Open/close
4.	All pyrometers - individual	In/out/on/off
5.	Turbine and SFPT manual Turning gear	Engaged/Disengaged
6.	FFP bags blinded	Variable
7.	FFP	In/Out of Service
8.	Oil purifiers	On/Off
9.	Fuel oil isolation, propane gas, fuel oil recirc etc	Open/closed
10.	All filters and strainers individual	Blocked
11.	All individual coolers	Leaking, blocking
12.	All 3rd party/black box systems	Open/closed On/off In/Out of Service
13.	Fuel oil isolation, propane gas, fuel oil recirc. etc.	Open/closed
14.	All associated key switches/field switches	On/off

3.25.3.4 External malfunctions

External malfuncitons

EXTERNAL FUNCTIONS		RANGE
A.	Ambient temperature	0 - 40 deg cel
B.	Circulating water inlet temperature	0 - 40 deg cel
C.	Wind speed and direction	Variable
D.	Coal Calorific value	Variable

E.	Coal bunker levels	0 - 100 %
F.	Coal ultimate analysis (carbon, hydrogen, oxygen, nitrogen, sulphur, moisture and ash content)	Variable
G.	Electrical system grid frequency	Variable
H.	Electrical system grid voltage	Variable
I.	Automatic dispatch megawatt demand (AGC)	Variable

3.25.4 Operating Envelope

The Simulator provided by the *Contractor* shall operate within realistic normal operating limits. If the simulation goes beyond these limits, misleading training may result. The system must therefore be equipped with administrative controls or other means that alert the instructor when parameters approach values that are indicative of events beyond the behavior of the applicable reference plant.

3.25.5 Verification and Validation Tool

The simulator provided by the *Contractor* shall be capable of being used as a verification and validation tool. The following refers to the minimum functional requirements of this capability:

a. Perform human factor engineering and development of operator interface design.
b. Perform preliminary failure and safety analysis.
c. Perform component sizing and capacity specification.
d. Perform virtual plant commissioning and verification of the integrated plant.
e. Perform DCS functional testing and tuning.
f. Verification and development of operating procedures.
g. Verify response to failures and faults.
h. Verify alarm response and identify alarm overload conditions.
i. Test DCS function block.
j. Create new logics/CMs and be able to upload and download into the system.
k. Replicate plant failures:
   1. Probes
   2. Transmitters
   3. Transducers
   4. Contacts
   5. Solenoids
   6. Analyzers
   7. Loop (breaks and failures)
   8. DCS: FTAs
   9. DCS: PMI/Os
   10. DCS: Controller

3.26 TRAINEE ENVIRONMENT

The operator interface provided by the *Contractor* should be a full replica in terms of size, shape, color, configuration and functionality of the hardware and displays in the reference plant. It should thus provide all the controls, indications and displays, alarms and other interfaces that are necessary to perform normal plant operation and to respond to malfunctions.

3.26.1 Operator Interfaces

Provision should be made for controls and displays other than those provided for on the operator interface that would function during normal operations or malfunctions. These controls and displays should closely resemble visual appearance and location that are found in the reference plant and functionally identically to it.

The following refer to some of these interfaces, but not limited to it:

a. Tube leak detection
b. Dust handling system
c. Bottom ashing systems
d. Relevant outside plant indications and controls
e. FLIP System
f. PTW System

3.26.2 Interfaces to third party systems

Grootvlei Power Station utilises two different control system for Boiler & Turbine control, thus the Boiler is equipped with the Honeywell DCS whilst the Turbine is equipped with the MAUELL system. These system needs to communicate to each other in order to ensure proper control and operation between boiler and turbine. The communication between these two systems was achieved by using an industrial automation protocol called OPC. OPC stands for OLE for Process Control, where OLE refers to Object Linking and Embedding.

The burner management system is a standalone system and forms part of the overall boiler protection system and interfaces to the reference plant DCS via the SCADA point.

The *Contractor* shall ensure that the interface of these systems is incorporated to the design and implementation of this upgrade.

3.26.3 Control room environment

The simulator control room environment should as far as possible be identical to that of the reference plant, in appearance and functionally. The following environmental factors should be considered or adhered to:

a. Replica of the control room in terms of dimensions and furnishings
b. Replica and location of control desk, operator interface, auxiliary equipment and furniture in the control room
c. Location and availability of communication equipment (phone and two-way radios)
d. Location and intensity of control room lighting
e. Availability of noise/vibration from the plant equipment

The operational requirements as specified in standard (Generation: Maintaining training facilities and equipment) shall be complied with.

3.26.4 Systems to be simulated.

3.26.4.1 Minimum plant model fidelity

All the simulator models provided by the *Contractor* shall meet the minimum fidelity requirements stated below. The systems to be included and the degree of simulation response are given below:

Category 1 - First-principle models, conserve mass, energy, and, where applicable, mechanical energy and angular momentum as constrained by the laws of physics.

Category 2 - Limited-scope models, will incorporate less-detailed, lumped models and engineering empiricisms, which at no time violate governing physical laws. All models include ambient losses, losses to enclosures, elevation effects and friction pressure losses, where applicable.

Category 3 - Logical models will only simulate the notable effects in a representative fashion.

Simulation response degree

FUNCTION	SYSTEM	SCOPE		
		CATEGORY 1	CATEGORY 2	CATEGORY 3
1. Boiler/Furnace System:				
	Boiler / Furnace System	X		
	Boiler / Furnace Protection		X	
	Boiler / Furnace Control	X		
	Boiler drum level control (2/3 element control)	X		
	Fuel Burning and Boiler Control System	X		
	Attemperator(s)	X		
	Safety Valves		X	
	Boiler Drains and Vent System			X
	Boiler Blow down System			X

	Unit Co-ordinator	X		
	Unitized Fuel Oil Plant			X
	Superheater	X		
2. Boiler Auxiliaries (Auxiliary Steam System):				
	Auxiliary Steam Tie and Controls			X
	Auxiliary Steam Piping, Headers and Control Valves			X
	Main Steam Pressure Reducing Station and Controls		X	
	Auxiliary Steam De-superheating Station and Controls		X	
3. Draught Group (Boiler Air And Flue Gas System):				
	Fan and Motor Controls	X		
	Fan Damper Controls	X		
	Precipitator/FFP		X	
	Air heater Soot Blowing			X
4. Boiler Combustion System (Coal Firing System):				
	Mills, Pulverisers and Controls	X		
	Air Fans and Controls	X		
	Secondary Air Controls	X		
	Burner Control System including permissive, interlocks and trip	X		
	Flame Safety System Management	X		
	Purge Permissive and Boiler Firing Permissive	X		
	Pulveriser Permissive	X		
5. Steam Turbine & Associated Systems:				
	Steam Turbine	X		
	Valve chest warm-up control by means of the ESV pre-lift valve	X		
	Admission pipelines and HP casing warm-up control	X		
	Turbo generator start-up and loading	X		
	Adjustment of the turbine speed to the grid frequency	X		
	Speed control	X		
	Load control, taking into account frequency bias	X		

	Initial pressure control	X		
	Limit pressure control	X		
	Primary grid frequency control respectively accurate speed control under islanding conditions	X		
	Safe turbogenerator recovery maintaining house load in the event of disconnection from the grid.	X		
	Acceleration detection	X		
	Bump less changeover of the operating mode of several parallel-driven servo drives (full-arc/partial-arc admission)	X		
	Online test programs for all protection components (ESV's and governor valves, reduced overspeed test, real overspeed testing)	X		
	Turbine Auxiliaries	X		
	Main Steam Stop Valves and Controls	X		
	Extraction Steam Valves and Control Valves	X		
	Main Shaft Driven Oil Pump			X
	AC Motor Driven Oil Pump			X
	DC Motor Driven Lube Oil Pump and Controls			X
	Lube Oil Reservoir, Filters and Lube Oil Cooler Controls			X
	Turning Gear Motor Controls			X
	Turning Gear Oil Pump			X
	Turbine Hydraulic System Skid and Controls			X
	Turbine Emergency Trip System	X		
	Turbine Gland Steam System	X		
	Steam Seal Feed Valve	X		
	Turbine Exhaust Hood Spray System	X		
	Turbine Drain System	X		
	Turbine Supervisory Instrumentation (TSI)		X	
	Turbine Protection System and Controls (Mauell)	X		
6. Condensate System				
	Unitized Condensate system	X		
	Condenser Vacuum Controls	X		

	Demineralized Water Storage Tank and Transfer Pump Controls			X
	Main Condenser Hotwell Level Controls	X		
	Condensate Hotwell pumps and Controls	X		
	Vacuum Breaker and Vacuum Pump Control	X		
	LP Feedwater Heater System and Controls	X		
	Deaerator and Deaerator Level Control System	X		
	Condenser Tube Side			X
	Condenser Priming System			X
7. Feedwater System				
	HP Feedwater Heaters and Controls	X		
	Boiler Feed Pump and Feed Pump Turbine and Controls	X		
	BFTP Auxiliaries			X
	Hydraulic Extraction Steam Controls			X
	Feedwater System Trips, Interlocks and Alarms		X	
8. Unit auxiliaries				
	Circulating Water System		X	
	Cooling/Service Water Systems			X
	Closed Cooling Water Pumps and Controls			X
	Closed Cooling Water Exchangers and Controls			X
9. Generator and Auxiliaries (Generator System)				
	Excitation System and Voltage Regulator		X	
	Excitation Control & Protection		X	
	Stator Cooling System and Controls		X	
	Generator Hydrogen System			X
	Seal Oil System including pumps, cooler, vacuum tank, piping and valves.			X
	Generator Protection System and Controls	X		
	Generator Synchronizing and Controls	X		
10. Other:				
	Dust Conveying/Handling System			X

	Bottom Ash Removal System			X
	Flue Gas Cleaning			X
	Tube-leak Detection System			X
11. Unit Electrical Reticulation (Unit Electrical Distribution System)				
	Unit Transformer			X
	Unit Auxiliary Transformer			X
	Transformer (4160 - 480 VAC)			X
	HV (138 KV) AC System			X
	MV (6900 or 4160 VAC) System			X
	LV (480 VAC) System			X
12. Unit Simulator				
	Distributed Control System	X		
	Instructor Station	X		

3.26.5 Remote function

Control and operating functions that are performed outside the control room or provide some input to the simulation models and are necessary to perform the reference plant's normal operations and malfunctions shall be simulated. The instructor shall be given an option to manually input or change such value during the normal running of the OTS.

3.26.6 External factors

Factors such as ambient temperature that exist outside the control room and affect the operation of the plant shall be controllable from the instructor's station and realistically affect plant operations in response.

3.27 SIMULATOR TRAINING CAPABILITIES

3.27.1 Instructor controls/features

The simulator provided by the *Contractor* shall be capable of freezing, the progression of all dynamic simulations at all times, initializing at predefined states, inserting malfunctions, and manipulate external parameters and remote functions.

In addition, the simulator provided by the *Contractor* shall provide the following features:

a) Snapshot

The ability to store particular conditions existing at any instant during a training session without interrupting any dynamic simulation that may be in progress and in order for such to be recalled in the future as an initialisation point.

b) Freeze/Run

The instructor station shall have an ability to control (freeze/run) all dynamic simulation conditions.

c) Record/Replay

The system shall be capable of activating a record/replay feature. The replay feature shall allow for the exact repeat in a semi-dynamic mode (replay of each backtrack) all of the indications in the same sequence for the most recent actions of the instructor as well as the actions of the operators.

d) Backtrack

The ability to periodically record the conditions of the Simulator on demand during a training exercise, while not in freeze, such that the instructor may initialize the Simulator may be initialised to a previous point in the simulation exercise.

e) Slow time

The ability to slow down the entire simulation, thereby providing the capability to observe the action of the simulation model and controls to specific conditions that are characterized by short time constants.

f) Fast time

A function to speed some lengthy plant evolutions and also return the speed to normal, which represent little or no training value, to move quickly to another point in the plant operation while retaining the continuity of the training exercise. (E.g. faster turbine warm up or cool down, faster boiler warm-up etc.)

g) Training monitoring/tracking

A student tracking feature shall be installed on the instructor station that allows tracking of student time and performance on the simulator. The instructor station shall be password protected and the student tracking feature shall keep records of the log on and of date and time of students and initial conditions used during their use of the simulator. This feature shall also support the automatic storing of the data for the Trainee Performance Review and Computer-Aided Exercises, under the student's name.

h) Trainee performance review

A Trainee Performance Review (TPR) program shall be provided, which will simultaneously monitor a minimum of twelve plant parameters and capable of recording the data.

A full audit trail capability shall be enabled where the trainee has to perform a complex plant operation (e.g. Unit start-up) on the simulator. It should have the ability to capture the baseline (“ideal”) set of actions to be undertaken, allowable timeframe for actions and correct execution sequence for the set of tasks; and then be able to monitor the trainee actions on the simulator against this baseline to identify and capture instances where the correct action, sequence or limited timeframe for the task was not achieved. This will enable training facilitators to institute remedial training to address deviations from expected baseline.

Performance Reviews and the audit trail capability of the simulator shall have reporting functionality enabled in order to generate the required training assessment and competency declaration reports that can be stored as evidence artefacts within the trainee’s development program (IDP).

i) Plant efficiency monitoring

The system shall have an ability to calculate and display both the unit heat rate and the effect of operationally controllable parameters on plant performance.

j) Stopwatch function

The simulator to be enabled with a stopwatch function that will allow the simulation to freeze when certain time/plant criteria are met.

k) Event logging

The system shall be capable of logging all simulation events including trainee and instructor actions.

l) Alarm activation

Allow initiating alarms without an abnormal plant condition.

m) Search help function

The instructor shall have the support of a search and help function that will cover all the required aspects of simulator configuration, operation and how to deal with potential fault conditions related to the simulator and its associated hardware/software.

n) Master alarm on/off

The instructor shall have the ability to silence the audible alarms installed on the simulator.

o) Simulator is in the freeze state

As each backtrack record shall be saved against the training exercise time and date and made available and displayed on a specific backtrack index table. The instructor shall be able to access and initialise any of the available records from the instructor's station, either by entering the time of the desired record or by manually or automatically stepping in either direction (forward or reverse).

p) Displays of simulated plant and parameters

The instructor shall be capable of monitoring and trending all simulated plant parameters on the instructor station.

q) Trending

The instructor shall be capable to trend a minimum of twenty variables on the instructor station with at least six of those variables present on the instructor screen at any one time. All plant variables shall be available for selection.

r) Computer-Aided Exercise

The instructor shall be capable of creating and initiating (running) scenarios or computer-aided exercises. A computer-aided exercise function (Intelligent Tutoring System) allows the instructor to predefine and permanently store a series of drills or operational problems. Each scenario shall be represented as a time-sequenced list of expert commands. This shall provide the instructor the ability to provide the same training for different operator trainees or to let the simulation run automatically.

3.27.2 Initial conditions

The simulator shall be capable of storing initializing conditions to support the specific user defined training objectives. The selection of these conditions shall be from the instructor station and the simulator shall be capable of adding, modifying, or deleting initializing conditions as required.

Typical initializing conditions are:

a. 0% Plant conditions. All auxiliaries out of commission, with zero pressure and ambient temperature.

b. Cold start (As per station cold start up criteria requirements).

c. Warm start (As per station warm start up criteria requirements).

d. Hot start (As per station hot start up criteria requirements).

e. Hot start up, after unit trip

f. Hot turbine – ready for synchronization.

g. Draughts on load and ready for purge.

h. Purge complete and ready for first fires in.

i. Turbine ready to turn on steam.

j. Boiler steam conditions ready – cold turbine on barring/turning gear.

k. Boiler steam conditions ready – turbine at various station/design run up speeds.

l. Turbine at 3000 rpm, ready to synchronise.

m. Boiler and turbine hot condition – ready for turbine over speed trip testing.

n. 1 X EFP in service, BFPT ready for run up

o. Two Boiler feed pumps in service and 1 Boiler feed pump on standby

p. Full load –with SFP in service where applicable

q. Full load – with EFP`s on load

r. Boiler conditions ready for safety valve floating

s. Unit start up loading conditions 25%, 50% and 75% of MCR.

t. Boiler and turbine ready for Simulation/interlock trip testing procedure.

3.27.3 Performance criteria

3.27.3.1 Steady state operation

Steady state measurement of the critical parameters on the simulator platform against the reference Unit approved steady state parameters on a variety of loading conditions will be performed, while the simulator maintains the steady load condition as follows:

a. At 40 % load for at least two hours
b. At 60% load for at least 4 hours
c. At 80% for at least 4 hours
d. At 100% load for at least 8 hours

The simulator-computed values of critical parameters shall be within 2% of the reference plant parameters explicitly stated in process units at greater than 25% load.

The calculated values of non-critical parameters agree with the reference plant's provided values within a tolerance of 5% of normal or full load values and do not detract from training.

Critical Parameters for Steady State Load

Parameter No.	Critical Parameter	Steady State Variation (%)
A.	Main steam pressure	1
B.	Main steam temperature	1
C.	Main steam flow	1
D.	Turbine control valve position	2
E.	Generator megawatts	2
F.	Feedwater flow	1
G.	Condenser vacuum	1
H.	Furnace pressure	2
I.	Feedwater temperature	1
J.	Superheater Attemperator/ Spray water flow	1
K.	Fuel flow	1

L.	Combustion air flow	1
M.	Boiler oxygen levels	5
N.	CO levels	1
O.	Air heater gas outlet temperatures	1
P.	Deaerator storage tank pressure and temperature	1

Note: The abovementioned values must be achieved as far as possible and any deviations from these values must be agreed on and formally approved by the Eskom Operating and Engineering representatives.

3.27.3.2 Transient operation

Simulator performance under transient conditions shall meet the following conditions:

a. The observable change in parameters shall correspond in time and direction to those expected from the best estimate for the simulated transient and will not violate the physical laws of physics.
b. The simulator shall cause an alarm or automatic action only if the reference plant would have caused an alarm or automatic action.
c. The simulator shall demonstrate realistic response to operator action.
d. The shape of any plant performance curve shall be similar to that of the operational power plant. The transient response of the displayed variables shall have slopes and trends that are characteristic of the actual power plant and shall have the proper time-dependants relationship to the related parameter.
e. In addition to specified tolerances, the shape of any plant curve shall be similar to that of the operational power plant. The transient response of the displayed variables shall have slopes and trends that are characteristic of the actual power plant and shall have the proper dependant relationship to the related parameters.

3.28 SIMULATOR CHARACTERISTICS

3.28.1 Life expectancy

a. The vendor/OEM and any other supplier shall provide the latest power plant proven technology for the Simulator system. No unproven technology shall be provided.
b. The life-cycle of the simulator system shall be in line with section 3.2.8 of 240-154243686 Technical Requirements for Power Plant Simulators Standard.
c. The PC and IT based equipment should be replaced only every five to eight years during its operational life, this strategy should be supported by the simulator OEM, and available as part of a service agreement, to minimise the effect of obsolescence and ensure seamless change over.
d. When migrating to a new platform in future, it will entail the retaining engineering work done as part of original project by the OEM.
e. The *Employer* participate in the necessary hardware and software upgrades as proposed by the OEM during the system life cycle.

f. The *Contractor* is responsible for any technical or software advances during the time of installation and commissioning must be offered to the client as part of the project. This will assist in keeping the simulator components at all the levels, relating to software and firmware as current as possible.

g. The *Contractor* shall provide maintenance /Service Support strategy offered by the OEM already at tender stage. It includes the necessary costing and other aspects based on the product life cycle of the total system.

3.28.2 Supportability

Support must be available throughout the simulator system life expectancy provided by the vendor/OEM, on request, throughout the life of simulator system. This includes but are not limited to:

a. Simulation environment (Process model)
b. Control and operator interface HMI environment
c. Instructor and development environment
d. Hardware support
e. Day to day service support
f. Spares and repairing of faulty equipment.
g. Technical support and training
h. Cyber Security incident containment, eradication and system restoration.

It is not the intention of the station to limit the supply of a simulator only to OEMs in this power plant simulation arena. This is done in an interest to reduce cost given that the value and system capabilities are not compromised.

Open Standards and protocols are to be used in the design of the system; this should lead to improved supportability.

It is required that the system be migrate-able/upgradeable while being backwards as well as forwards compatible at the different levels of the system.

3.28.3 Reliability and Availability

The system shall be designed for 96.71% availability, measured annually. From the date the hardware is energized.

No single system failure mode shall repeat itself more than once every twelve months.

Any updates and patches at construction should be tested and proven reliable by the OEM before updating Grootvlei equipment.

No redundancy shall be required for the components or sub-systems of the Simulator, unless if the lack of such redundancy will violate the reliability and availability. The reliability and on-site spares holding of all components within the Simulator system shall support this availability figure.

3.29 MAINTAINABILITY

a. The *Contractor* is responsible for the maintenance of replaced equipment until officially handed over to Eskom. The simulator *Contractor* shall supply a simulator system with diagnostic and test software to perform online and off-line diagnosis of all simulator hardware, software, peripheral and communication faults. The faults shall be logged and used to assist with fault finding.

b. The diagnostic and test software provided shall also assist in the resolution/repair of all faults detected.

c. The *Contractor* shall provide maintenance training for Eskom employees before execution of the replacement. Training for the server setups, diagnostics and maintenance regimes shall be given to ensure compliance with warranty conditions.

d. Engineering and maintenance training should focus on system administration, backups, new logic configuration and testing, logic changes downloads, navigation and fault finding.

e. Engineering and maintenance staff require training on server maintenance, fault finding, backup and archiving, server replacement and switch configuration.

f. A maintenance strategy complete with recovery procedure is to be provided for backing up and recovery of a system in case of system failures. This includes verification and testing of backups.

g. All maintenance manuals, datasheets, training documents must be supplied by the *Contractor* before acceptance of replaced equipment.

h. Server failure emergency response procedures are required. This should include a hard drive replacement procedure. Ensure synchronisation and RAID configuration is maintained between servers. The procedure supply maintenance instructions for all self-diagnostic warnings and alarms

i. The *Contractor* provides a list of critical spares required for day-to-day maintenance. Standardisation between units and Simulator equipment must be maintained as far as possible to minimise spare holdings.

   1. The system should include online diagnostics that should show any and all failures at the different levels of the simulator.
   2. Any special equipment needed for maintenance and engineering must be provided as part of the simulator delivery, together with training on this equipment.
   3. Should any software, engineering or configuration change be made it must only be necessary to do this from the development environment.
   4. Any changes made through the development environment to applications, configuration and programs must be logged by the system.

3.30 EXPANDABILITY

The Simulator *Contractor* system design shall allow for later expansion such that future changes and enhancements can be readily incorporated. The following shall be provided at completion/hand-over of the Simulator system:

3.30.1 Hardware

a. The utilisation of all CPUs (servers, workstations and controllers) shall be less than 50% under normal operating conditions.
b. The utilisation of all networks shall be less than 50% under normal operating conditions.
c. The storage utilisation of all storage drives (hard-disk or solid state) installed within servers and workstations shall be less than 50 %.
d. Memory utilisation of all servers and workstations shall be less 50 % under normal operating conditions.
e. All switches shall have 10 % spare, unused ports (rounded up to the nearest integer).
f. The IO module shall have 10 % spare, unused IO (rounded up to the nearest integer).
g. All Simulator cabinets shall have 10% spare, unused 1U rack space available (rounded up to the nearest integer).

3.30.2 Software

a. Where applicable, software spare capacity shall be no less than 30 %. This includes all IO and soft PLC/AP-related licenses.

3.30.3 Power

a. The simulator system shall have 20% reserve power availability per power supply system (power distribution, cabinet power supplies).

3.30.4 Upgrades/Replacement Systems

The product life cycle of the simulator is expected to fit into the product life cycle of the simulator OEM. All upgrades and maintenance patches shall at all times be running at the same version as the reference plant.

3.31 DESIGN LIFE

The simulator design life in this project is expected to be at least for 5 to 8 years.

3.31.1 Standardisation and interoperability

There is an international simulator related standard (ANSI/ISA-77.20) that is applicable to this project, and Eskom also has a generic USR for simulators. This document is drafted in accordance with both ANSI/ISA-77.20 and the Eskom generic USR for simulators.

3.31.2 Functional Interfaces

The station prefers a traditional physical server installation. However, a virtual installation environment can also be considered given that the supplier can guarantee that the system performance will not be affected. 1 Gigabit Ethernet ports and in particular TCP/IP based interfaces will be the only acceptable interfaces on the system.

3.31.3 Safety Requirements

In terms of safety related standards, the Eskom safety rules shall be complied with during this project (PPE, lifesaving rules, any other safety related campaigns and regulations, etc).

3.32 PLANT CODIFICATION

Coding of the design will be based on the AKZ/KKS coding system and the *Contractor* will undertake the coding in line with 240-93576498 KKS and 240-109607736 Eskom KKS Key Part Eskom Standards.

The KKS coding shall be applied during the design reviews stage(s) and across referenced to all arrangement drawings, schematics and wiring diagrams. The *Contractor* will be required to include allocated coding to electronic design drawings.

3.33 SECURITY

The *Contractor* ensures that the Simulator security design comply with section 3.2.5 of 559-577223024 Generation Cyber Security Standard for Operational Technology. The replacements must allow software updates to ensure security is maintained to latest version, such as malware definitions and patch management of all software and operating systems.

3.34 LICENCES

a. All licenses covering the equipment, standard software and application software provided are included as part of the works supplied by the *Contractor*.
b. Licenses are permanent and are site licenses used at Grootvlei Power Station.
c. Licenses remain valid in the event of failure and replacement of faulty equipment.
d. Licenses for equipment provided includes *Contractor*'s Sub-*Contractor* and they are valid for the entire life of the Simulator.
e. Installation disks and license keys are provided for all licensed software.

3.35 UPGRADES

Upgrades of software and the associated licences are provided throughout the duration of the works supplied by the *Contractor*.

All software patches, bug fixes and software upgrades for the system are provided throughout the duration of the works supplied by the *Contractor*.

3.36 WARRANTEES

All warranties for the equipment, standard software and application software provided are included as part of the works supplied by the *Contractor*.

All warranties are in the name of Grootvlei Power Station.

3.37 REMOVAL OF EXISTING EQUIPMENT

3.37.1 General

a. The *Contractor* decommissions the hardware currently installed at the Simulator Trainee workstation, server room and instructor room and hand them over to the *Employer*.

b. Other equipment declared scrap will be removed and transported to the dedicated disposal areas at Grootvlei Power Station.

c. Where the *Contractor* removes equipment, the *Contractor* provides as part of the *works,* the restoration of floors, tiling and other applicable plant items to the state agreed with the *Employer*.

d. All removed equipment is transported by the *Contractor* to the areas specified by the *Employer.* All such areas are located within the boundaries of Grootvlei Power Station.

e. All equipment and material that is removed is deemed re-usable and remains the property of the *Employer.* Where equipment and/or cabling has been removed, the area needs to be restored in accordance with the requirements of the *Project Manager.*

3.38 TRAINING

Training forms one of the major project deliverables; the project shall include client approved training that is designed to cater for the following major groups:

The following participants are to be trained:

Maintenance :5

Engineering : 5

Instructor Training : 3

The *Employer* bears the cost of salaries, accommodation travelling expenses and other allowances of his personnel during the training, all other training cost are borne by the *Contractor*.

The *Contractor* provides additional (repeat) training courses as and when instructed by the Project Manager.

3.39 INSTRUCTOR TRAINING

Accredited instruction training shall be provided, which shall include but not limited to;

a. Navigation training
b. Platform training
c. Functional training
d. System operation training

e. Maintenance tools and diagnostic tools training

Training documentation shall be provided to the OPS training section in electronic and hard copy format (scanned electronic copies not acceptable).

Operating training shall be phased in the project execution to ensure instructor personnel competency to provide effective simulator training.

3.40 MAINTENANCE TRAINING

Maintenance training shall be provided and documented in detail by the *Contactor* and covers the entire simulator equipment configuration (hardware and software), and upon completion, the trainee shall be declared competent by the vendor to perform the following maintenance functions on the simulator system as a minimum:

a. Updating and modification of control system engineering (control logic and HMI)
b. Updating and modification of the control system emulation configuration
c. Updating and modification of the plant model
d. Updating and modification of the audio & video system
e. Tools for hardware and software diagnostics and fault finding.
f. Administration tools
g. Back and restoration process of the entire simulator setup
h. Disaster recovery process of the entire simulator setup
i. Patch management and anti-virus updating via the Central Update Server
j. Hardware cleaning
k. Hardware replacement
l. Hardware configuration
m. Software updates
n. Software modifications
o. Software configuration

1) Training documentation shall be provided to the Maintenance training section in electronic and hard copy format (scanned electronic copies not acceptable).

2) Maintenance training shall be phased in the project execution to ensure that maintenance personnel competency to provide effective day to day maintenance support.

3) Provision will be made for maintenance staff to be involved during the project processes of detail design, set-up to operational testing to become competent on the maintenance aspects of the simulator.

3.41 ENGINEERING TRAINING

Engineering training shall be provided and documented in detail by the *Contractor* and covers the entire simulator's equipment and its configuration (hardware and software).Upon training completion, the trained engineer shall be declared competent by the vendor to perform the following modifications to the simulator system as a minimum:

a. Navigation training

b. Platform training
c. Functional training
d. System operation training
e. System administration training
f. Maintenance tools and diagnostic tools training
g. Engineering or development tool training
h. System configuration and management training
i. Design philosophy training
j. Fault finding training.
k. Hardware and software training
l. Updating and modification of the plant model
m. Tracing of process streams in the model and how are linked to the main DCS/HMI screens.
n. Updating and modification of control system engineering (control logic and HMI)
o. Updating and modification of the control system emulation configuration How to edit the model components (create new ones, compiling the main code, startup the system, etc.).

Training documentation shall be provided to the Engineering training section in electronic and hard copy format (scanned electronic copies are not acceptable).

Engineering training shall be phased in the project execution to ensure that engineering personnel competency to provide effective day to day maintenance support. Provision will be made for engineering staff to be involved during the project processes of detail design, set-up to operational testing to become competent on the engineering aspects of the simulator.

3.42 DOCUMENTATION

3.42.1 Requirements

The *Contractor* provides documentation as specified in the VDSS and the standards.

3.42.2 Documentation Management

The Technical documentation covers all stages of the works.

The language of all documents shall be English.

The *Contractor* shall include the *Employer*'s drawing number in the drawing title block. This requirement only applies to design drawings developed by the *Contractor* and Subcontractors

The *Contractor* will work with the *Employer*'s configuration department in developing the drawing numbers for the drawing and equipment codes for the works.

3.42.3 Document Submission

1) All project documents must be submitted to Project Manager with transmittal note according to Project/Plant Specific Technical Documents and Records Management Work Instruction (240-76992014)

2) All documents used within the project follow the same standards of layout, style and formatting.
3) The *Contractor* is required to submit documents as electronic and hard copies and must be delivered to the Project Manager with a transmittal note. The transmittal note must have the following minimum, fields:
   i. Name of the Package
   ii. Name of the *Contractor*
   iii. Transmittal number
   iv. *Contractor* Details
   v. Date of submission
   vi. Response date
   vii. Description of the document
   viii. Document Number
   ix. Document media type
   x. Number of copies
   xi. Purpose of the submission
1) The *Contractor* shall maintain a master document list capturing all documents issued to the *Employer.*
2) Soft copies and hard copies of each document specified in section 3.9 of 240-158191826 Generation Operation Training Requirements Specification for Power Plant Simulators and the VDSS are provided by the *Contractor*. Documents are provided at the stages defined in the VDSS.
3) 3 hard copies and 2 soft copies (1 pdf and original CAD format) of "As built" documentation shall be provided by the *Contractor* as part of the works.
4) Acceptance of the "As Built" documentation by the *Employer* is a pre-requisite for the Sectional Completion of the plant Area concerned. Computer Aided Design (CAD) drawings are provided during the various stages of the project can be edited and viewed using Bentley Micro station; version is agreed with the *Employer*.

3.42.4 Cabling Documentation

The *Contractor* provides the cable documentation for control and power cable for the works.

The *Contractor* transfer all cable schedule information in electronic format.

3.42.5 Failure to supply documents and manuals

Commissioning will not start until commissioning documents are accepted by the Project Manager.

3.42.6 Constraints

There are two main/major constraints that have been identified in this project, thus being:

1. Time (project schedule/delivery), due to urgent need for training of operators, the expectation is that the project must be delivered in a short space of time.
2. Budget/funding, the project is currently not funded as it was not included in the Life Of Plant Plan.

3.43 TECHNICAL RISKS

Based on the learnings from the previous Grootvlei simulator projects, the unavailability of all input documentation such as equipment design datasheets, performance curves (valve characteristics, pump curves etc), mass heat balance and process flow diagrams, this will lead to poor performance of the model design resulting to a simulator that is not high-fidelity and high realism in terms of functionality, capability and behaviour as per the reference units design philosophy.
In order to address the above risk, C&I Engineering, Design and Specification and other system owners has embarked on the process of acquiring these documents. This will involve going to site documentation centre and also looking into the Eskom's archive centre.

In the event where the input or design documents are unavailable, the *Contractor* and the Employer will have to agree to develop the model using the historian data of the reference unit for modelling of the specific plant.

3.44 STANDARDS

The standard specifications applicable to the works are listed in the table of standard specification in APPENDIX I.

The *Contractor* shall obtain own copies of International and National standard specification document.

The *Employer* standard specification documents are obtained from the Project Manager.

4. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation
Mantombi Mkemezulu	Grootvlei C&I Engineering Manager
Thabo Montja	Grootvlei Middle Manager Engineering
Zithulele Sibiya	Grootvlei Middle Manager Operating
Owen Ngcobo	Officer Education &Training
Audrey Choshi	Officer Education &Training
Christoph Kohlmeyer	Chief Engineer (C&I)
Khaya Sobuwa	Gx Corporate Specialist, C&I
Cornelius Visagie	Chief Technologist (C&I)
Azwimbavhi Mamanyuha	General Manager Special Projects
Moddy Mashiloane	Documentation Centre

5. REVISIONS

Date	Rev.	Compiler	Remarks
July 2024	0.1	R Mali	First Draft
September 2024	0.2	R Mali	
October 2024	1	R Mali	Incorporated the inputs from IDR comments
April 2025	2	R Mali	Incorporated the technical evaluation strategy for 2 packages on section 3.1

6. DEVELOPMENT TEAM

The following people were involved in the development of this document:

7. ACKNOWLEDGEMENTS

Khaya Sobuwa
Christoph Kohlmeyer
Cornelius Visagie
Ndumiso Nxumalo
Nonhle Shibe
Dumisani Chauke
Bothata Mokoena

APPENDIX A: EXISTING SIMULATOR DEFECT LIST

INDEX	PRIORITY
1	Coordinator vs Pressure control to be operational to function and operate accordingly
2	Loading from barring to full load without simulations
3	Loading from 200MW to off load without simulations
4	Be able to start the draught group plant with one draught on load.
5	Put any Mill in service or take it out without getting abnormal value from all mill or furnace related parameters
6	Model the coal flow to the Mill feeder properly (under all conditions)
7	Drum parameters should not be affected in an abnormal manner when introducing auxiliaries or loading the unit
8	All draught group response components shall respond according to the reference plant when loading, de-loading or starting the auxiliaries.
9	Model all furnace components properly such that all furnace parameters show realistic response
10	Ensure that all plant projections operating as required
11	All system or plant alarms values to be configured correctly
12	All boiler protections and auxiliaries to operate as required
13	Plant trip philosophy to be adhered to at all times
14	The air heater together with all the fire fail (Tx 012is indication only not trip) and alarm to operate correctly
15	Model the entire turbine plant together will all the auxiliaries correctly
16	All turbine measurement shall be made available according to how they are showing on the reference plant (during run up, loading, steady state, full load, de-loading, trip, shutting down and standing still conditions)
17	Mill ram cylinder press, trip and alarm to be model correctly
18	Tube leak detectors and all the respective alarms to be configured according to the reference plant
19	All EFP trip to operate correctly as stated in the philosophy
20	Seal/Oil DP to be model correctly and it must give a realistic performance matching that of the reference plant
21	Condenser level transmitter dashboards to be included on the HMI

22	Gen seal oil\H2 to be configured so that is functions according to the plant philosophy
23	All stator coolant parameters, trips and alarms to function correctly
24	All snapshots to have the same alarms and trips values every time they the same snapshot is restarted
25	The load master valve position to operate properly
26	On Unit1 - "Propane as system"- OOSCB25CP001 Instrument Air Pressure indication is not showing
27	10HAD10FL00154/55 - Drum level HIGH alarm occurs during the boiler pressurization, even when the level is normal.
28	10HLA52AA001- After starting the Mills, PA fan secondary air damper stays at 30% and doesn't go to 100% on its own.
29	All mill alarms, RAM cylinder pressure alarm and trip values are different from the Unit1 database.
30	EFP discharge flow and Amps are on higher side than the usual value measured and the Feed water control station.
31	During the Turbine Casing warming using Auxiliary steam, Temperature transmitters on the Chest of Turbine like 1OMM80CT001XQ01 is raising
32	During Turbine load up, as we reach 200 MW, when the boiler pressure SP is 10.5MPa, the pressure increases up to 11.5 MPa and then slowly comes down. Boiler pressure control is slow.
33	During shutdown, main steam temperature increases more the 560 degrees C and cross the trip point
34	Mill capability value is 50 and is different from the values (40) available in Unit 1 database.
35	Oxygen measurement at the outlet of air heater is the same as that of the Oxygen content at the inlet. In the real Unit, there is a leakage of air in the air heater and hence Oxygen content at the exit of the air heater is higher than the inlet.
36	To push the Unit on Co-ordinate control, MT target load and pressure SP should go to Co-ordinate mod automatically
37	Boiler trip- The final steam temperature rise to rise to 600 degrees C, drum pressure at 11.24 MPa and final steam pressure at 11.57MPa and air heater gas inlet drops to Left Hand side 200 degrees C and Right hand side 199 degrees C
38	Cold start- Air heater gas inlet temperature rise abnormally fast will one bank of oil burners

39	Cold start - Gland steam system has no effect on the turbine expansion
40	Cold start - Final steam temperature response is quick
41	Cold start- Turbine vibrations on the bearing temperature response is minimum and the model seems to be simplified.

APPENDIX B: FAILED BOILER ALARM RESPONSE LIST

INDEX	ALARMS
1	Furnace press fail high/low
2	Drum lvl high/low
3	Final steam temp
4	Air heater fire
5	Mill ram cylinder
6	Tube leak
7	Draught group trip.

APPENDIX C: FAILED TURBINE ALARM RESPONSE LIST

INDEX	PRIORITY
1	EFP leak off flow low
2	Seal oil press low
3	Seal oil/H2 diff
4	Stator coolant inlet flow
5	Stator coolant head tank lvl’s
6	HP HTR dist 1 to LP HTR at low load fail.
7	Rotor earth fault not available.
8	Load master valve position fails to operate for manual reverse power trip.
9	H2 gas press high fail (No alarm or trip values coming through on DCS or from process upset).
10	Stator inlet temp high fail (Not available on DCS or process upset).
11	HP diff trips but no alarms on alarm screen and can’t be done at process upset.
12	HP thrust temp high no alarm or trip to DCS and can’t be done at process upset.
13	LP exhaust temp neither on DCS nor at process upset.
14	Rotor temp high no alarm/trip and no display.
15	Leak detector level high can’t be done.
16	EFP flow high can’t be done.
17	Stator conductivity can’t be done. (Trip and alarm not coming through.

APPENDIX D: SCENARIOS - TOP SEVEN PRIORITY SCENARIOS

INDEX	TOP SEVEN PRIORITIES SCENARIOS
1	Vacuum decay: Scenario 1
2	Turbine vibrations: Scenario 1.
3	Pyro protection operation: Scenario 1
4	Drum level trips: Scenario 1.
5	Loss of fuel oil: Scenario 1.
6	Mills running empty. Not possible
7	Loss of indication. Not possible.

APPENDIX E: SCENARIOS - PROCEDURE TRAINING

INDEX	PROCEDURE TRAINING
1	Unit safe guarding after trip
2	Pyro cleaning procedure
3	Air heater fire alarm
4	One draught group trip
5	Mill start up after a mill trip
6	Mill emptying process after unit trip
7	Mill normal start up/shutdown
8	EFP Start-up & shutdown
9	Draught group start up/shutdown
10	SFP Start up/Shutdown
11	Boiler tube leak detector alarm activated

APPENDIX F: SCENARIOS – OPERATIONAL EXPERIENCE AS PER OPS SUPPORT

INDEX	OPERATIONAL EXPERIENCE AS PER OPS SUPPORT
1	Unit Coordinate Control Mode Selection
2	
3	
4	

APPENDIX G: SCENARIOS – BOILER ALARM RESPONSE PROCEDURES

INDEX	BOILER ARP'S
1	Boiler furnace pressure low alarm
2	Boiler furnace pressure high alarm
3	Boiler drum level low alarm
4	Boiler drum level high alarm
5	Mill ram cylinder N2 gas pressure low alarm
6	Boiler furnace flame failure temperature low alarm
7	Mill lube oil pressure low alarm
8	Stack emissions high alarm
9	Final steam temperatures high alarm
10	Air heater gas outlet temperatures high alarm
11	Mill diff pressure high alarm
12	FFP cell diff pressure high alarm
13	FFP bag pulsing pressure low alarm
14	Equipment room fire protection alarm

APPENDIX H: SCENARIOS – TURBINE ALARM RESPONSE PROCEDURES

	TURBINE ARP'S
1	H2 Generator casing pressures high alarm
2	LP Turbine exhaust steam temperature high alarm
3	Deaerator storage tank level low alarm
4	Deaerator storage tank level high alarm
5	Main condenser level low alarm
6	Main condenser level high alarm
7	HP Heater 1 distillate level high
8	HP Heater 2 distillate level high
9	HP Heater 3 distillate level high
10	EFP discharge flow low alarm
11	EFP Discharge flow high alarm
12	Stator coolant pumps discharge pressure high alarm
13	Seal oil pressure low alarm
14	Stator coolant tank level low alarm
15	Main turbine thrust bearing temperature high alarm
16	HP Turbine diff expansion alarm
17	Stator coolant inlet flow low alarm
18	H2 /seal oil diff pressure low alarm
19	Stator coolant outlet temperature high alarm
20	Stator coolant conductivity high alarm
21	Generator liquid leakage detector alarm
22	Generator rotor earth fault alarm
23	Generator /unit transformer conservative tank level low alarm

APPENDIX I: CODES AND STANDARDS

No	Standard	Description
1	ANSI/ISA77.20.01-2012	Fossil Fuel Power Plant Simulators: Functional Requirements
2	36-1422	User Requirement Specification for Fossil Fired Power Plant Simulators
3	240-154243686	Technical Requirements for Power Plant Simulators Standard
4	240-158191826	Generation Operation Training Requirements Specification for Power Plant Simulator
5	240-159991017	Virtualization of Control Systems Technology Standard

APPENDIX J: VDSS

Grootvlei Power Station Operator training simulator replacement project

C	=	The *Contractor* submits the documents to the *Employer* as a deliverable for either, Completion or starting, of the applicable Activity
(yellow shading)		The document is not required for this C&I system. The document with the same DOCUMENT REF from the First PI's documentation shall apply to this C&I system.
(green shading)	=	The document is maintained by the *Contractor* and available to the *Employer* on request
E	=	The *Employer* submits the document to the *Contractor* as a deliverable
(yellow shading)	=	The document is maintained by the *Employer* and available to the *Contractor* on request

SIMULATOR — **TECHNICAL DOCUMENTATION REQUIREMENTS** — ⟵ (First Character of Revision No. in Document No.)

DOCUMENT SET		DOCUMENT REF NO.	(Revision No. in this column)	COMPOSITE DOCUMENT	DOCUMENT DESCRIPTION	High Level Eng Philosophies & Concepts	Technical Clarification Pre-requisite Documents	Simulator Design Freeze Documents	Technical Clarification Pre-requisite Documents	Detailed Eng Design Freeze Documents	Simulator FAT Pre-requisite Documents	Simulator FAT Completion Documents	Erection & Installation Pre-requisite Documents	SIT Pre-requisite Documents	Simulator SIT Completion Documents (Phase 2			Training on system and training manuals	"AS BUILT" Document Package (Phase 3	LIVE documents	Native / Original Software Format (SYSTEM = documents generated by the Contractor's C&I system	REMARKS
						BASIC ENGINEERING B			DETAILED ENGINEERING D		MANUFACTURING M		PROCUREMENT AND INSTALLATION E			COMMISSIONING C	OPTIMISATION A	TRAINING	COMPLETION A			
CFG17			**		SIMULATOR SYSTEM DATABASE(S)			C		C		C			C				C		DB	
			**		SIMULATOR FUNCTIONAL SPECIFICATION		C	C											C		WORD	
			**		SOFTWARE INVENTORY (LISTING ALL SOFTWARE PACKAGES, VERSION NUMBER, LICENSE INFORMATION,ETC...)		C	C				C							C		EXCEL	
			**		EQUIPMENT SCHEDULE (LISTING ALL EQUIPMENT USED FOR THE SIMULATOR)		C	C				C							C		EXCEL	
			**		OVERVIEW NETWORK ARCHITECTURE		C	C											C		CAD	
			**		PHYSICAL NETWORK CONFIGURATION DRAWINGS		C	C				C							C		CAD	
			**		LOGICAL NETWORK CONFIGRUATION DRAWINGS		C	C				C							C		CAD	
			**	NETWORK DESIGN	NETWOR CABINET INTERNAL LAYOUT & POWER DISTRIBUTION WIRING DRAWING		C	C				C							C		CAD	
			**		SIMULATOR DATA REGISTER		C	C											C		WORD	
			**	SIMULATOR DATA	MODEL PARAMETERS		E	C											C		WORD/PDF/CAD	
			**		SIMULATION DIAGRAMS						C	C							C		CAD	
			**		FAT PROCEDURES					C											WORD	
			**		SAT PROCEDURES					C											WORD	
			**		SIT PROCEDURES					C											WORD	
			**	ACCEPTANCE TESTS PROCEDURES	PROCESS AUTOMATION SYSTEM APPLICATION SOFTWARE VALIDATION PROCEDURE		C			C											WORD	
			**		'AS BUILT' ACCEPTANCE TEST PROCEDURES					C					C						WORD	
			**		VAT PROCEDURES					C									C		WORD	
SIMULATOR			**		DESIGN REPORTS						C	C							C		WORD	
			**		PRE-FAT TEST REPORTS					C											WORD	
			**		FINAL FAT REPORT							C									WORD	
			**	ACCEPTANCE	FINAL SAT REPORT										C						WORD	
			**	TESTS REPORTS	FINAL SIT REPORT										C						WORD	
			**		FINAL PROCESS AUTOMATION SYSTEM APPLICATION SOFTWARE VALIDATION REPORT														C		WORD	
			**		FINAL "AS BUILT' ACCEPTANCE TEST REPORT														C		WORD	
			**		FINAL VAT REPORT																WORD	Submitted by Contractor after each VAT
			**		SIMULATOR ENGINEERING AND MAINTENANCE PROCEDURES (HOW TO DOWNLOAD C&I DATABASE TO SIMULATOR, ETC...)		C	C				C							C		WORD	
				USER GUIDES	INSTRUCTOR/MAINTENANCE/ENGINEERING MANUALS		C	C											C		WORD	
			**		SOFTWARE MANUALS		C	C											C		WORD	
			**		HARDWARE MANUALS		C	C											C		WORD	
			**		INSTALLATION DISKS OF ALL APPLICATION SOFTWARE AND ENGINEERING SOFTWARE PROGRAMS														C		ELECTRONIC MEDIA	
			**		SOFTWARE LICENCES														C		ELECTRONIC MEDIA	
					TRAINING SCHEDULE		C	C													WORD	
			**		COMPLETION CERTIFICATES														C		PDF	