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1. Introduction

Renewable (green) hydrogen production is a key priority to achieve net zero carbon emissions by 2050 in South Africa. It will directly contribute to Eskom's decarbonisation strategy and enable renewable energy deployment as it presents an excellent medium for long-term energy storage. Eskom already has experience in operating small kW electrolysers at the Power Stations to produce grey hydrogen, however there are still various challenges across all areas to integrate the value chain and produce renewable hydrogen, at medium and large scale (megawatt to gigawatt size) that needs to be resolved.

Developing a pilot Renewable Hydrogen Facility (RHF) will present Eskom with an informed pathway to plan for the adoption of green hydrogen at a scale, time and cost that is competitive against alternate options such as hydrogen produced from fossil fuels (grey hydrogen). It will also present Eskom with an opportunity to understand legislative requirements and regulations related to renewable hydrogen, and to develop skills through Eskom's participation in the key national initiatives in South Africa such as the South African Hydrogen Society Roadmap and South African Hydrogen Valley.

2. Supporting Clauses

2.1. Scope

Eskom Research, Testing and Development (RT&D) requires the engineering design, procurement, and construction (EPC) to be conducted for a hydrogen generation plant to form part of the RHF at Eskom Research and Innovation Centre (ERIC), in Rosherville. The hydrogen generation plant should be modular and integrated with the existing solar Photo Voltaic (PV) plant and Battery Energy Storage System (BESS) to form a RHF.

The hydrogen generation plant to be supplied must consist of five sub-systems:

1. Electrical Configuration,
2. Energy Management System,
3. Hydrogen production, (including water demineralisation and storage)
4. H_2 storage,
5. H_2 End use workstation.

The entire hydrogen system must comply with the Eskom's Hydrogen systems standard (240-56227413), where deviations are expected this must be declared during tendering.

2.1.1. Purpose

The purpose of this document is to provide the technical specification/Works Instruction for the design, procurement, testing, commissioning, and handover of the hydrogen generation plant which is to form part of the integrated Renewable Hydrogen Facility at ERIC. The plant health of the cell stacks must be monitored and the data recorded in order to evaluate the impact on the cell stack health as part of a RHF application.

2.1.2. Applicability

This document shall apply to the Renewable Hydrogen Facility at the Eskom Research and Innovation Centre.

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 Systems
[2] OSH Act 83 of 1995: The Occupational Health and Safety Act 83 of 1995.
[3] 32-520 Occupational Health and Safety Risk Assessment Procedure
[4] 32-95 Occupational Health and Safety Incident Management Procedure
[5] 240-56227413 Hydrogen Systems Standard
[6] 240-56536505 Hazardous Location Standard
[7] 240-49230046 Failure Mode and Effect Analysis (FMEA) Guideline
[8] 240-49230030 Reliability Engineering Analysis Guideline
[9] 240-49230111 Hazard and Operability Analysis (HAZOP) Guideline
[10] 240-56364545 Structural Design and Engineering Standard.
[11] 240-53113685 Eskom design review procedure
[12] 240-44682650 Process Control Manual to Provide Engineering during Project Sourcing.
[13] 240-53665024 Engineering Quality Manual
[14] 240-53114026 Eskom Project Change Management Procedure
[15] 240-53114002 Engineering Change Management Procedure
[16] 240-98784903 RT&D Quality Management System Manual Document Identifier
[17] 240- 86973501 Engineering drawing standard
[18] 240-71432150 Plant Labelling Standard
[19] 240 -60782552 Process Flow Standard
[20] 240-56355754 Field Instrument Installation Standard
[21] 240-56355815 Control & Instrumentation Field Enclosures and Cable Termination Standard
[22] 240-56356376 Site commissioning for low pressure services
[23] SANS 10108: Classification of Hazardous Location (Electrical Plant)
[24] 240-56227443: Requirements for control and power cables for power stations

[25] 240-57617975: Procurement of Power Station LV Motors Low Voltage Electric Motors
[26] 240-56357424: MV and LV Switchgear Protection Setting Standard
[27] 240-56364444: Standard Minimum requirements for Metering of Electrical Energy and Demand.
[28] 240-56227516: LV Switchgear Control Gear Assembly Associated Equipment for Voltage – 1000 V AC and 1500 V Standard
[29] 240-56356396: Earthing and lightning Protection Standard
[30] 240-55714363: Coal Fired Power Stations Lighting and Small Power Installation Standard
[31] 240- 56241933 Control of Welding during Construction, Repair and Maintenance Activities Standard
[32] 240-106628253 Standard for Welding Requirements on Eskom Plant
[33] 32-373 IT and OT Third Party and Remote Access Standard Rev 5
[34] 240-79669677 Demilitarized Zone Designs for Operational Technology Rev 2
[35] 240-55410927 Cyber Security Standard for Operation Technology
[36] 240-56737448 Fire Detection and Life Safety Design Standard
[37] 240-54937439 Eskom Fire Protection / Detection Assessment standard
[38] 240-56737654 Inspection Testing and Maintenance of Fire Detection Systems Standard
[39] 240-56355910 Management of Plant Software
[40] IEC 62381 Automation systems in the process industry - Factory acceptance test (FAT), site acceptance test (SAT), and site integration test (SIT)
[41] 240-145581571 Standard for the Identification of the Contents of Pipelines and Vessels
[42] 240-165573930 Hydrogen plant pressure equipment preparation and pressure testing
[43] 240-56355728 Human Machine Interface Design Requirements Standard
[44] 240-56355541 C&I Computer and Equipment Rooms Civil and General Building Requirements Guideline
[45] 240-56355888 Temperature measurement system installation standard
[46] 240-56355843 Pressure measurement system installation standard
[47] 240-115583001 LV Switchgear Technical Schedule A&B
[48] 240-56360086 Stationary Vented Nickel Cadmium Batteries Standard
[49] 240-56360034 Stationary Vented Lead Acid Batteries Standard
[50] 240-51999453 Standard Specification for Valve-Regulated Lead Acid Cells
[51] 240-53114248 Thyristor and Switch Mode Chargers

2.2.2. Informative

[1] 240-RTD126 Research Testing and Development Renewable Hydrogen Facility Concept Design Report
[2] 240-RTD-124 Stakeholder Requirements Definition for Renewable Hydrogen Facility
[3] 240-53114193 Occurrence and Incident Management Procedure
[4] 240-53114192 Corrective and Preventive Procedure
[5] 240-53114194 Control of Nonconforming Product Procedure
[6] 240-53114190 Internal Audit Procedure

2.3. Definitions

Renewable (Green) Hydrogen	-	Renewable hydrogen is produced by water splitting via electrolysis and produces only hydrogen and oxygen. The electricity supply for electrolysis should be from renewable energy sources
Grey Hydrogen	-	Natural or synthetic gas is separated into hydrogen and carbon dioxide, while the carbon dioxide is emitted into the atmosphere
Contractor	-	Company Successful in obtaining a contract with Eskom as defined in Eskom Procurement and Supply Management Procedure: 32-1034.
Employer	-	Eskom Holdings
Equipment List	-	A list of codes allocated to components for each scope of delivery or system, this list shall but include documents such as cable schedules, valve schedules, etc.

2.4. Abbreviations

Abbreviation	Explanation
AC	Alternating current
AIAA	American Institute of Aeronautics and Astronautics
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ABD	Availability Block Diagram
bar	Bar
BESS	Battery Energy Storage System
BOM	Bill of materials
C&I	Control and instrumentation
CAD	Computer-aided design
CM	Configuration management
CMS	Control and Monitoring System
CoE	Centre of Excellence
CoC	Electrical Certificate of Compliance
CPU	Central processing units
DC	Direct current
DVD	Digital versatile disk
ECA	Electrical Contractors' Association
EPC	Engineering design, procurement, and construction
ERIC	Eskom Research and Innovation Centre
EWDL	Engineering Work Design Lead
FAT	Factory Acceptance Testing

Abbreviation	Explanation
FMECA	Failure Mode Effects and Criticality Analysis
GA	General Arrangement
GPS	Global Positioning System
GUI	Graphical User Interface
HMI	Human Machine Interface
HVAC	Heating ventilation and air conditioning
IEC	International Electrotechnical Commission
IED	Intelligent electronic device's
ISO	Internation Organisation for Standards
ITP	Inspection and Test Plans
kA	kiloampere
kPa	kilopascal
kW	kilowatt
kWh	kilowatt hour
l/h	Litres per hour
LDE	Lead Discipline Engineer
LOSS	Limits of Supply and Services
LV	Low voltage
mA	milliampere
MCB	Miniature Circuit Breakers
MCCB	Moulded Case Circuit Breakers
MDT	Mean Down Time
MTTF	Mean Time to Failure
MTTR	Mean Time to Repair
MV	Medium Voltage
MWh	Megawatt hour
O&M	Operational and maintenance
OEM	Original Equipment Manufacturer
OHS Act	Occupational Health and Safety Act
PSR	Plant Safety Regulations
P&ID	Piping and instrumentation diagrams
PV	Photo Voltaic
QCP	Quality Control Plans
R&D	Research and Development
RAID	Redundant array of independent disks
RAM	Reliability, Availability and Maintainability
RE	Renewable energy
RHF	Renewable Hydrogen Facility
RT&D	Research, Testing and Development
SANS	South African National Standards

Abbreviation	Explanation
SCADA	Supervisory Control and Data Acquisition
SIL	Safety Integrity Level
UPS	Uninterruptible power supplies
USB	Universal serial bus
VDSS	Vendor Document Submission Schedule
VPN	Virtual private network

2.5. Roles and Responsibilities

Engineering Work Design Lead (EWDL) - is responsible for compiling the Technical Specification.
Gas and Renewables Centre of Excellence (CoE) Manager - is responsible for reviewing and authorising the Technical Specification.
Lead Discipline Engineer (LDE) – Provide discipline specific specifications for the Works Information.
Contract Manager – Will be responsible for the management of the contractor appointed to implementation of the Works Information

2.6. Process for Monitoring

The process for monitoring will comply with the Design Review Procedure (240-53113685) and Process Control Manual to Provide Engineering during Project Sourcing (240-44682650). The procedure will be monitored via 240-53665024: Engineering Quality Manual and self-assessments and Project Definition Readiness Assessment. Areas where the Engineering Quality Manual does not allow for Pilot & Demonstration (excluding safety aspects), the project will not comply to the procedure, but to an equivalent procedure that does allow for Pilot and Demonstration.

2.7. Related/Supporting Documents

N/A

3. General Requirements

3.1. Project Description

Eskom Research and Innovation Centre in Rosherville was chosen as the preferred location and is in the south of Johannesburg, near the N3 and N17 highways, see Figure 1. The facility also falls in an industrial hub with Transnet and other industries nearby that can be used to drive the hydrogen economy.

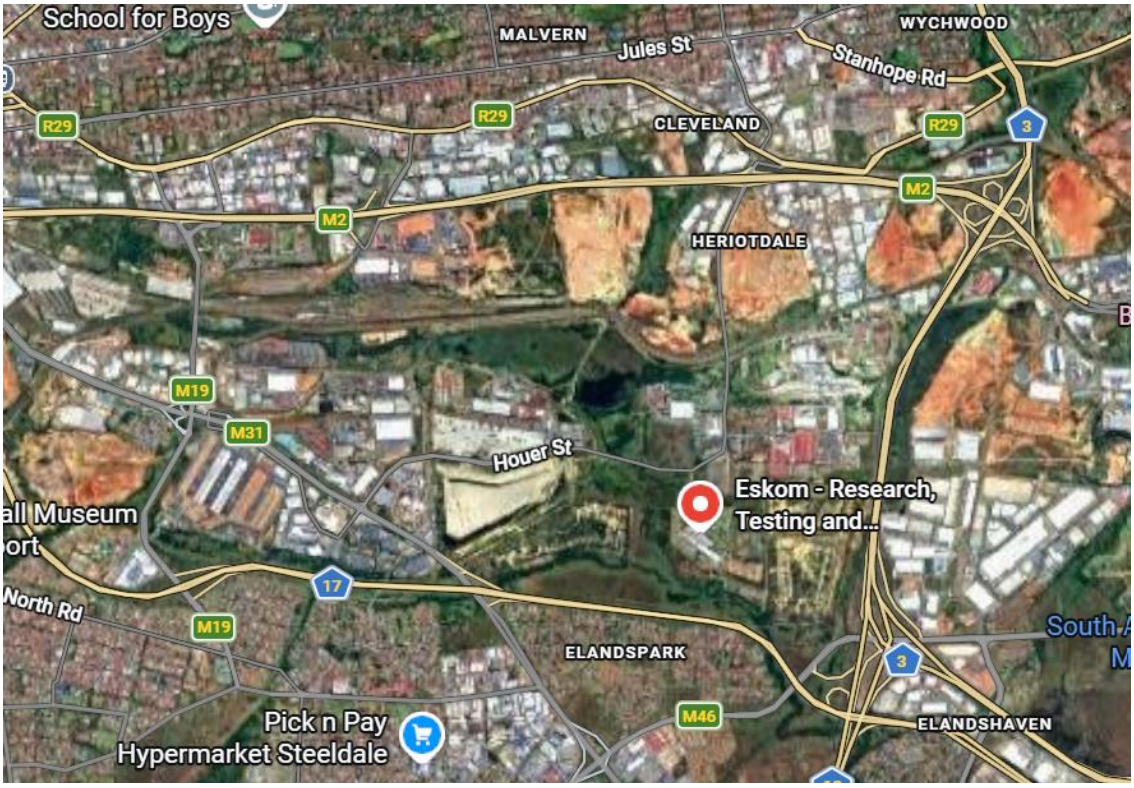

Figure 1: Eskom Research and Innovation Centre (ERIC) Location, Rosherville, Johannesburg, South Africa

The infrastructure already installed at ERIC enables Eskom to develop a renewable hydrogen facility (RHF). Electrolysis is predominantly used to produce Renewable Hydrogen and can be easily integrated into the existing system, as proposed in the concept of the RHF is shown in Figure 2.

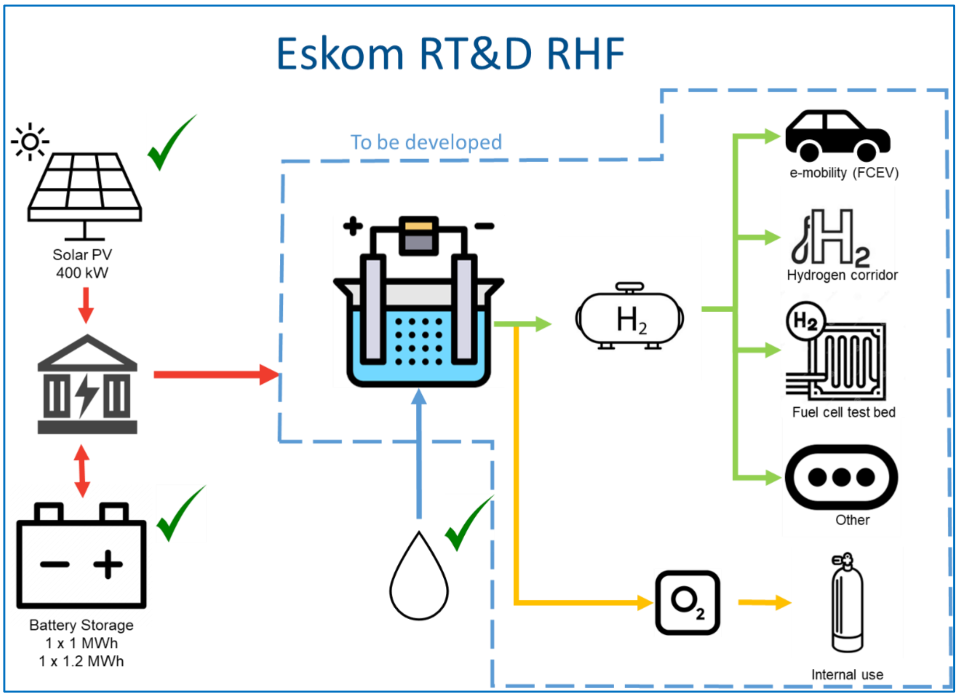

Figure 2: RHF Proposed Layout

The infrastructure available at the ERIC facility that can integrated and interfaced with the hydrogen generation plant, is shown in Figure 3 below and includes:

1. 400 kW solar Photo-Voltaic (PV) plant,
2. 2.2 MWh battery storage, (consisting of two units, one with a capacity of 1.2 MWh, discharge rate of 200 kW and 78-81% roundtrip efficiency. The other unit has a 1 MWh capacity, discharge rate of 200 kW and 65 – 72% roundtrip efficiency)
3. Electrical network via the NW substation
4. Municipal water supply (the demin water plant as illustrated below will not be included in the overall RHF
5. Fire detection and protection system,
6. IT network, and
7. maintenance, security and other support.

Figure 3: ERIC, RT&D premises at Rosherville for RHF implementation

The hydrogen generation plant must be located next to the solar PV plant on the eastern side as shown on the image, since this will allow ease of access from the main entrance and will also have the visual benefit of an integrated system.

The R&D plant will be used for technology understanding within an integrated system, training and skills development and the application of regulations and standards for green certification, as well future end use research. The project will entail the integration of the electrical configuration, electrical management system and the operation of the electrolyser(s). This will enable practical research to establish the optimal configuration between renewable energy requirements and batteries capacity, for a desired electrolyser(s) availability, while avoiding premature electrolyser degradation. The production of 'Green hydrogen' can also be used to stimulate end use application in the area.

3.2. Contractor Requirements

The EPC contractor must demonstrate experience in engineering, procurement and construction contracts for electrolysis and hydrogen storage plants. This can be demonstrated by providing project detail of successfully executed projects including: the name of company where the project was executed, project description, construction period, operational performance of that plant, contract value, contact person, contact number, contact email (contactable reference from projects already executed).

Where the EPC Contractor will use a sub-contractor, the scope of the subcontractor must be clearly defied during the tendering phase. The full company profile and work experience of the sub-contractor must be provided as per the paragraph above.

The original equipment manufacturer (OEM) for all major plant and equipment must be stated during the tendering phase. The details of the local agents for the electrolyser as well as other major plant and equipment must be provided. Details of the local service and maintenance capability of these local agents as well as spares holding must also accompany the tender. Direct communication channel between the end-user and OEM for technical support must be possible and facilitated by the contractor. The contractor must also provide details on the frequency of OEM's visits to South Africa to audit end-user satisfaction with the local agent.

The Contractor must ensure that only qualified personnel with the relevant experience (relevant to this project and technology utilised) are included in design, construction, commissioning, and operation of the plant. The contractor is to provide detailed CVs of each personnel responsible for the works including the project organogram to indicate the role of each person on this project. The CV's submitted during tendering will be evaluated, therefore, if any replacement is required during the course of the project, the Contractor will be required to submit the CV of the replacement for evaluation and acceptance. This is to ensures that the replacement has equivalent or higher experience and qualifications than the resource that is being replaced.

3.3. Scope of Work

The scope of work describes the major activities, plant and material that falls within the scope of the Contractor. It is the responsibility of the Contractor to ensure that all the activities are carried out and all equipment, plant and materials are supplied to complete the works in every respect. The contractor will be required to design, source, supply, install and commissioning a Hydrogen Generating Plant which is fully compliant to the specification 240-56227413: Eskom Hydrogen Systems Standard. Compliance is required to be illustrated as part of tender submission i.e. P&IDs, control philosophy and detailed maintenance manuals.

The Works comprise the complete detailed engineering design, manufacturing, sourcing and supply of mechanical, process, electrical, control and instrumentation (C&I), civil and structural work, shipment, transportation, unloading, erection, quality assurance, on- and off-site testing, painting, finishing, installation, integrations with existing infrastructure, testing, commissioning, onsite operational training, certification and handover, and hazardous zone classification of the hydrogen generation plant. The Works include all matters which, although not expressly provided for, can be reasonably inferred from the contract for the final plant needed. The only exclusions being items or services excluded or specifically stated to be free issued or to be provided by the Employer or by others.

3.3.1. Contractors Scope

The works comprises the following:

a) On commencement of the contract the contractor is to submit a schedule indicating key deliverables and date, for approval by the contract manager.
b) The Contractor's registered professionals shall provide services in accordance with ECSA Code of Conduct (Act No. 46 of 2000) and guidelines for registered professionals as well as the Construction Regulations (Act No. 85 of 1993).
c) The contractor will complete a Detailed Engineering Design for the hydrogen generation plant in line with 240-56227413 Hydrogen System Standard and the plant specific requirement detailed in this Works Information. (Note: All plant, materials and equipment are required to be designed to a minimum requirement for maintenance and operator intervention)
d) As part of the contractor's design, a hazardous zone classification must be done, and the classification report submitted to the Contract Manager for approval. All electrical and C&I equipment selected for the classified areas must comply with the area classification requirements and applicable standards. The design must cater for minimising the electrical and C&I equipment in hazardous zones by locating this equipment in less hazardous zones.
e) The contractor will generate the QCP and ITP indicating all hold points. This package will be reviewed and approved as part of the detailed design.
f) This design will be submitted to Eskom for a Detailed Engineering End-of-phase Review. (as per the end-of phase design review in the 240-53114002: Engineering Change Management Procedure). All review comments and recommendation will be submitted to the contractor to update their design before the design can be signed off and finalised.
g) Only after sign-off of the detailed design by Eskom may the contractor commence with procurement, manufacture or supply of equipment.
h) The contractor will be required to include site establishment for the required facilities to be used by the contractor. This will include all earth work as determine to be necessary during the detailed design.
i) The contractor is fully responsible for transportation, delivery, offloading and securing assets prior to or during construction at ERIC. Acceptance and sign off of all delivered equipment must be facilitated by the contractor. All assets must be kept in a secure location until required for installation.

j) The contractor is fully responsible for all construction and installation activities this is to include rehabilitation, waste removal and disposal during the construction and commissioning phase.
k) The contractor is responsible for the design and connection of all interfacing and integration points with existing plant. This include both physical connections as well as data transfer and acquisition system, as detailed in this document. Should an outage be required for this activity the contractor will make the necessary arrangements with the contract manager. Outages need to be scheduled well in advance (2 months at least for electrical), as it entails shutting down power to some critical other RTD services. These are to be minimised to be the bare minimum
l) Commissioning, testing and optimisation activities must be carried out in the presence of the appointed Eskom representatives. The Contractor shall test and submit all performance data as proof that the installed Works meet the Employer's requirements, standards and specifications.
m) The contractor must supply a portable impedance measuring meter.
n) The contractor must supply a spare cell stack or set of cells stacks, prepared for long-term storage (5 years). The long-term storage procedure must be submitted as part of the tender submission.
o) All special tools required for the maintenance activities shall be supplied.
p) The contractor must provide training of the Employer's personnel in the operation and maintenance of the hydrogen generation plant, as well as administration and engineering of the system. This can include classroom training but must be primarily based on site with the fully installed and commissioned equipment. Training should continue for a period of 1 month or until the Eskom personal can be certified as competent and technical assistance must be provided for all defect or warranty claims after handover.
q) Handover of the plant to Eskom will take place after the Eskom personal are fully trained and competent. During handover the contractor must provide as-built drawings, operating and maintenance procedures, training manual and list of critical spares.
r) During construction activities all Safety, Health, Environmental and Quality requirement must be adhered to in line with this works information and local legislation.
s) The contractor is fully responsible for all other activities as detailed in this works information including plant labelling, corrosion protection, safety and plant signage, access control.
t) All quality requirements must be met in term of the quality management system and documentation management requirements as detailed in the works information.

3.3.2. Functional Specification for Plant

In addition to complying with the requirements of 240-56227413 Hydrogen System Standard the plant consists of the following (illustrated in Figure 4):

a) Complete hydrogen generating plant.
    - Power supply unit: The power requirement for the electrolyser and auxiliary plant should be between 50kW and 65kW. (The power requirement for the facilities is not included in this limitation).

- The Proton Exchange Membrane (PEM) or Anion Exchange Membrane (AEM) water electrolysis technology is preferred for the RHF. Pressurised Alkaline Electrolyser shall be considered as an alternative.
- The configuration could be at 1 x 50kW electrolyser, with multiple cell stacks (minimum two) or smaller electrolysers, that provides a total hydrogen output of approximately 24kg/day at a 99.9% purity. If more than one electrolyser is installed it should be independent with the ability to operate and test them separately.
- The hydrogen produced shall be at a minimum pressure of 27 bar with no compression and have minimum purity of 99.9% by volume and a dew point of 50°C or better at 101.4 kPa.
- Balance of plant and interfacing designs, manufacturing, as well as installation of piping, joints, fittings, valves, and instrumentation must conform to all requirements as stipulated in 240-56227413: Eskom Hydrogen Systems Standard.
- The contractor must provide cell stack close loop cooling and gas close loop cooling.
- The hydrogen generation plant must include all auxiliary plants as prescribed by the OEM including but not limited to, deminerilize water plant and storage, H_2 gas dryer, heat exchangers, etc. (Municipal water will be supplied to the Hydrogen plant)
  - Water Demineralization water treatment plant must have conductivity monitoring.
  - Demineralization water tank must include flushing facility before plant startup.
- A heated dryers is not a requirement for the RHF but a de-oxidiser with heating element is.
- Safe plant operation must be ensured by on-line monitoring and data logging of all critical parameters, gas analysing and automatic control of the hydrogen system. The hydrogen generating plant needs to be controlled by a dedicated control system and the bulk storage, metering, and reticulation needs to be controlled by a separate control system with the required interfaces between the two control system in order to ensure safety.
- The design of the hydrogen generating system must prevent unnecessary stopping of the plant to optimise cell stack life expectancy and limit venting to atmosphere. The control philosophy must consider plant operational limits that are not a safety related issues, under these conditions it is preferable that the plant reduced production rate rather than trip.
- Inert gas purging facilities: In accordance with 240-56227413 Hydrogen System Standard, during system failure the plant must be purged with nitrogen prior to restart. Therefore, the automatic nitrogen supply system must be incorporated into the design.
- The hydrogen plant must be within a cabinet, in a container with all associated H_2 production equipment. The H_2 plant is considered to be a temporary / mobile plant that can be relocated to a different site in future. This container must include a heating, ventilation and air conditioning (HVAC) system as required to control the temperature and humidity within the container during operations and to ensure there is no accumulation of gas at any point within the container.

- The contractor is to supply all consumables and critical spare required to perform a repair within 48hours for the first two years of operations. A full service must be done in month 23 and shall form part of maintenance training.

b) The Hydrogen generation plant must indicate what the safe turndown rate is, under safe operational condition. Allowance should be made for the employer to test the plant below the design turndown rate, in a controlled manner to assess the limit. Safety control limits on the gas purity should not be compromised during such testing, the plant should trip automatically when unsafe conditions are reached.

c) A flexible and adjustable energy management (load profile) system must be provided to simulate a renewable load following profile to test the plant under variable load conditions. Allowance should also be made for the electrolysers to load-follow the PV plant's electricity production to allow for ramp-up and ramp-down capability testing via control panel.

d) The C&I integration / interface with the existing PV Solar plant and BESS must allow for future green certification. Therefore, the SCADA system must include a smart metering system to measure or account for renewable energy (as per certification requirements), i.e. the system must record power production from the PV plant and charge / discharge profiles for the BESS (state of charge and power profile) to allow for a calculated net green hydrogen production. The monitoring system must measure the power consumption of the hydrogen generation plant (with auxiliaries) and the power consumption of the facility (domestic circuit, control room, etc) separately. (The hydrogen facility will draw power from the central substation, where the PV plant and BESS are connected. It is not a requirement that the Hydrogen generation plant be directly connected to the PV Plant and BESS).

e) The hydrogen production plant needs to be set-up as a research plant with the required additional on-line monitoring and data logging with an uninterruptable power supply and can be independent of the hydrogen production plant control system.
    - The plant health of the cell stacks must be monitored and a data recorder must be provided in order to capture the data to evaluate the impact on the cell stack health as part of a RHF application.
    - The cell stacks need to be supplied with on-line voltage monitoring and data logging between each anode and cathode, therefore the cell stack needs to provide voltage monitoring points for each anode and cathode. These measuring points shall be wired to a terminal box located outside the process plant. The measuring points shall be clearly marked, and location on each cell stack indicated on a drawing.
    - A portable impedance measuring device shall be supplied with the supply of the plant. The individual cell voltages and impedances shall be measured and recorded as part of the FAT. The current density throughout the cell stacks must be measured and recorded. The data must be downloadable in an excel file format and clearly identified.
    - It will be required that different load profiles to be uploaded to the hydrogen generating plant in order to evaluate the performance of the cell stacks under different conditions (Hydrogen production capacity vs time).
    - Each hydrogen production plant output purity must be measured to 0.1% accuracy, including oxygen content and must form part of the safe plant operation philosophy.

- The hydrogen purity directly after each cell stack shall be measured in ppm. The hydrogen content within the oxygen stream shall be measured in ppm. These values shall be through on-line instrumentation for data capturing.
- Control and instrumentation. On-line water temperature monitoring exiting cell stack and entering the water demineralization water treatment plant.

f) Hydrogen metering and pressure reducing station must be provided.

g) The new plant and metering panel must be hosted in separate containments (cabinets) with the required ventilation to dilute hydrogen leakages to outside flammable mixture and monitoring, hydrogen leak and fire detection that reduces the risk of a flammable or an explosive mixture accumulating.

h) Contractor's design and supply scope shall include:

- Hydrogen Generating Plant related drawings, control philosophy, operating and detailed maintenance manuals package,
- Receiver valve, metering panel and five multicylinder pack connection panels (including flexible hose connections to cylinder packs) design, drawings, control philosophy, operating and detailed maintenance manuals package. (Typical example of a metering panel is provided in Appendix A).
- Automatic inert gas purging connection panel.
- Bulk storage vessel and metering panel manual purging connections and multicylinder connection panel including flexible hoses and pressure regulators etc.
- Demineralized water treatment plant.
- A hazardous zone classification must be done and the classification report submitted.
- Integrate the plant with the required available facilities i.e. current water supply systems, electrical supply connections and the storage vessels.
- Integrate the control and monitoring of the new plant with control centre.
- All electrical and C&I equipment selected for the classified areas must comply with the area classification requirements and applicable standards.
- The design must cater for minimising the electrical and C&I equipment in hazardous zones by locating this equipment in less hazardous zones.

i) All control and monitoring data must be accessible via remote login.

j) Hydrogen bulk storage

- H_2 storage must be at the electrolyser operating pressure. (no additional compression)
- The hydrogen storage must be provided and shall not exceed 80 m^3 with a minimum operating pressure of 27 bar. Three storage tanks each with a capacity of 24m^3 must be supplied, this is to ensure that total storage capacity remains below the trigger for an environmental authorisation.
- The produced hydrogen should be continuously dried and stored in a bulk storage vessel.

k) An end-user testing facility must be provided. This should be a containerised facility which is a laboratory type workspace and should cater and testing of end-use application, (i.e. fuel cells, small desk / lab scale devices, hydrogen appliances etc.) on a "plug and play" principle. This location will be open for the testing of future technologies. This facility must be equipped with 5 test benches with hydrogen connection points, and access to overall plant test data. The facility must be designed to allow staff occupation in the facility during testing, therefore it must contain benches and chairs, windows, ventilation, lighting and air conditioning.

l) A container must be provided as a control room which will house all electrical and monitoring equipment.
   - An additional independent roof structure must be installed above this container to provide addition temperature control. This roof structure must extend beyond the container (along the length and at the entrance) to create a shaded area the same size as the container to allow for group gatherings under cover.
   - All containers should include HVAC system and an appealing "green" look.

m) The contractor is to make provision for roads and parking, access control to the facility (which should include a 2m fence and lockable gate), lighting, security cameras, all associated civil works, electrical works, mechanical installations, reticulation, valves, cabling, cable racks, instrumentation, monitoring systems, software, etc as defined in this works information.

n) Fire protection and detection system must be integrated with the existing system at ERIC. Local alarms and strobe must also be provided at the facility, that must be visible for security or any passer-by.

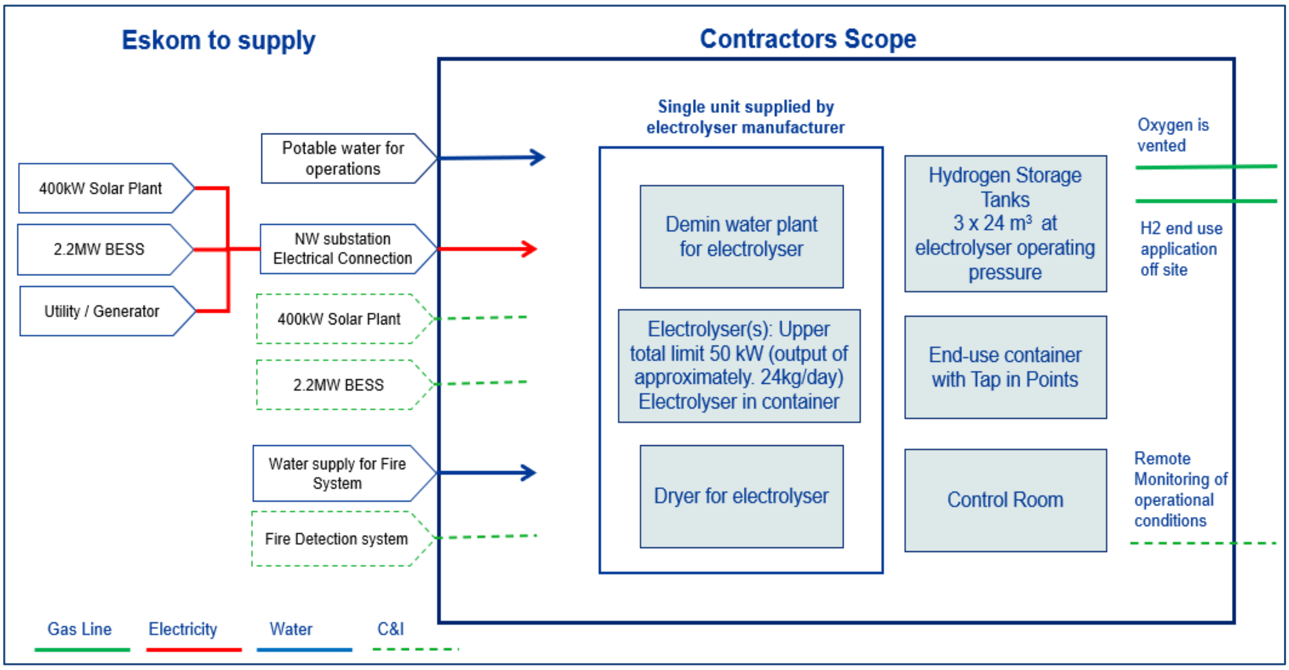

Figure 4: Block flow diagram of the main elements of the scope of work.

3.3.3. Additional Requirements

The following additional requirements are for noting:

a) Where the document is not clear about the work to be performed, it is the Contractor's responsibility to confirm requirements with the Employer's Contract Manager and Engineering representative via Request for Information process. The Contractor Shall only act upon confirmation by receipt of an Engineering Instruction via the Contract Manager. Incorrect work done (where Engineering Instructions were not issued) shall be moved/removed/replaced/changed/reinstalled by the Contractor at his cost.
b) All referenced Eskom Standards shall be made available to the Contractor.
c) The contractor is to comply with the 240-53113685 Eskom Design Review Procedure and Project Engineering Change Management Procedure in addition to the Contractor's own engineering governance processes.
d) Defects and maintenance (after commissioning but before handover) to be done by the contractor. There will be a defect period of 52 weeks after hand over.

3.3.4. Limits of Scope and Supply

The Limits of Supply and Services (LOSS) and the termination points are specified in the LOSS Diagram in the documentation package. Where these limits are not explicitly specified it is the Contractor responsibility to liaise with the Employer to determine the location and details for all the terminal points. The Contractor shall comply with the connection details of the lead discipline when completing the detailed design, the design of the connections shall be approved by the relevant parties which are responsible for the supply of services up to the relevant terminal point.

Other Limits of Supply and Services for the completion of the Plant may arise as the detailed design progresses and shall be provided by the Contractor within the Contract price.

3.4. Safety Requirements

The contractor shall comply to the most stringent requirements applicable in the latest revision of Eskom Hydrogen Systems Standard, site specific procedures and stipulations of the OSH Act.

3.5. Quality Requirements

3.5.1. Quality Management System

The project shall be subject to International Organisation for Standards (ISO) ISO 9001 Quality Management Systems Standard and will be subjected to internal Eskom and external certification audits. Compliance with the following procedures is required, RT&D Quality Management System Manual Document Identifier: 240-98784903 and Eskom Quality Management policies and procedures. The procurement and project quality requirement shall also comply Eskom Supplier Quality Management Procedure: QM58.

Quality Control Plans (QCPs) / Inspection and Test Plans (ITPs) indicating respective hold points, witness points and review points must be submitted by the appointed Contractor for approval by the Employer. This will be used to ensure that an Employer representative is present for the inspection of the various activities during the construction, installation, commissioning, and handover of the plant.

3.5.2. Inspection

Inspection activities and hold points during manufacturing and construction shall be managed according to the QCP and ITP agreed upon by the Contractor and the Employer in the Project Schedule.

The Contractor shall be required to maintain inspection databases where all records of inspection are maintained as required quality management systems.

3.5.3. Data Books

The Contractor shall develop and implement a system for collation or quality verification records, including change management records, into Manufacturing, Construction and Commissioning Record Books (Data Books).

Data Books shall be maintained by the Contractor to substantiate conformance to product specifications and requirements. All records shall be safely stored (easily retrievable) following the final completion of the works at handover. These records shall include as a minimum:

- Quality Management documentation as specified in the Quality Management Requirements
- Safety clearances (to be granted prior to commissioning)
- Construction, layout and component approvals
- Routine test certificates
- Construction and as-built drawings and approvals
- Statutory certification
- Data Books (Record Books)

3.6. Drawing Requirements

The creation and control of all Engineering Drawings shall be in accordance with the latest revision of 240-86973501 (Engineering Drawing Standards – Common Requirements). The Contractor shall provide detailed “As Required” arrangement/dimensional drawings for each part of work to be done. No work will commence without approval of these drawings approved by the Contract Manager and Engineering representative of the Employer.

After the works has been completed, detailed “As-built” drawings shall be provided by the Contractor. The “As-built” drawings are subject to the Employer’s Engineering representative comments and approval. All drawings shall indicate all the new installation/modified parts as well as enough of the existing pipework to which the items are connected. This shall be done in sufficient detail to easily identify the location of the installation.

All drawings shall contain the following as a minimum:

- Description of component with labelling number.
- Layout of the pipework with dimensions and angles.
- Bill of materials (BOM) for all components traceable to the layout. BOM should include size, schedule, pressure rating or class, material, quantity etc.
- Design and operating pressures and temperatures.
- Proof Pressure Test requirements and pressures.
- Design Code.
- All drawing revisions must be provided as paper copies in original (in all cases at least A3) size as well as provided in .pdf format.
- All drawing must also be provided in Computer-aided design (CAD) format such as DGN (or similar digital format).

All required drawings shall be prepared in accordance with the requirements as specified in the Engineering Drawing Office and Engineering Drawing Standard (240-86973501). A drawing register (Master Document List, with document titles, document revision, status, transmittal details and project phase) which records the drawing's information shall be maintained by the Contractor.

The contractor is to provide a document list, showing format, project phase of when review is required. Drawings to be prepared will include and not be limited to:

- Equipment drawings,
- Equipment lists,
- Isometric drawings and piping and instrumentation diagrams (P&ID),
- Electrical Drawings,
- Loop drawings,
- Cabinet drawings,
- Cable schedule,
- Data sheets,
- Calibration certificates,
- Acceptance test procedures,
- Network architectures,
- Location drawings,
- Instrument list,
- Equipment list,
- Critical spares list,
- Original Equipment Manufacturer (OEM) manuals and part catalogues,
- Set point and parameter lists,
- Three dimensional drawings requirements - DGN model.

3.7. Configuration Management Requirements

3.7.1. Configuration Management Plan

The Contractor shall prepare a configuration management (CM) plan utilizing ISO 10007 as a reference guide for the scope of work. The CM plan shall include the following:

- A complete and comprehensive description of the Contractor's document numbering conventions and revision schema.
- A description of the electronic data management system(s) that the Contractor will use for the management of documents and/or configuration items.
- A description of the configuration management activities which will be undertaken by the Contractor as well as a rough timescale thereof.
- A description of the baselines that will be established and the content of these baselines.
- The release procedure for product configuration information.
- The method for processing changes, emanating both internally and from sub-suppliers.
- The method for collecting, recording, processing and maintaining the data necessary for producing configuration status accounting records.
- The definition of the content and format for all configuration status accounting reports.
- A list of audits which will be conducted to ensure adherence to the CM plan.

3.7.1.1. Plant Labelling

The plant signage, posting and labelling requirements are stipulated in the Hydrogen System Standard (240-56227413)

- Each Hydrogen system and control areas must have signage, placards, postings, and labels displayed, so employees shall be aware of the potential hazards in the area. The location of Hydrogen systems shall be permanently placard as follows:
    - HYDROGEN-FLAMMABLE GAS-NO SMOKING- NO OPEN FLAMES
    - Each portable container shall be legibly marked with the name "HYDROGEN". Each manifold Hydrogen supply unit shall be marked with the name "HYDROGEN" such as: "This unit contains Hydrogen" (OHSACT; NFPA). Placards must be of sufficient size and colour that they are readily visible to employees entering the work area.
- All plant to be fitted with the KKS labelling consistent with the Eskom standards for unique identification.
- Coding shall be used on all drawings, isometrics, schedules, documents, operating and maintenance manuals.
- The identification of contents of pipelines shall be in accordance with 240-145581571.
- Identification shall include colour banding, code by stencilling or labelling and flow direction arrows.
- All pipework shall be provided with markings, labels or colour coding indicating the contents thereof.

3.7.1.2. Plant Designation within Documentation

The Contractor shall prepare a list of codes allocated to components for each scope of delivery or system (this list shall be referred to as equipment list in the rest of this document for simplicity, but includes documents such as cable schedules, valve schedules, etc.). The equipment list shall be submitted with the original implementation documentation describing the design of the system (e.g. process and instrumentation diagram, single line diagram, etc.). The Contractor shall ensure that the equipment list accurately represents the implementation documentation which it accompanies. The content of the lists will be agreed to per discipline with the Employer. As a minimum, the equipment list shall include:

- The labelling codes of all components within the relevant scope or system,
- The full verbal description of each component,
- The abbreviated description of each component,
- The approval status of each component, in alignment with the list of approval statuses specified for document.

3.7.2. Documentation Submission

All documents shall be submitted to the Project manager, the language of all documentation is required to be in English. The Contractor shall submit the Vendor Document Submission Schedule (VDSS) to the Project manager. The VDSS is revisable, and changes shall be discussed and agreed upon by all parties and properly documented. Changes in the VDSS include additional documentation to be submitted, changes in submission dates, corrections in documentation descriptions and document numbers; etc. The contractor shall be responsible for the management of the schedule i.e., to create a document register that shall be used to plan and track submission progress of documentation as per the committed dates on the VDSS.

3.7.3. Transmittal

The Contractor shall list all project documents (soft copies and hard copies) for submittal on the transmittal with the following metadata fields:

- Title of the document,
- Document Unique Identification number,
- Revision number,
- Name of Discipline,
- Reason for issuing/submission,
- Sender’s detail,
- Sent date,
- Recipient’s Details,
- Date received,
- Quantity of documentation referenced on the transmittal,
- Number of copies,
- Format/medium submitted (e.g.: paper, Flash drive, Electronic Transfer, etc.),

- Sender signature, and
- Recipient signature, once submitted, to acknowledge receipt.

Drawing numbers shall be assigned by the Employer as drawings are developed. The project name shall be listed on all drawings, including manufacturers' drawings. A separate sheet may be attached to the submittal if needed to adequately list all tag numbers associated with the drawings such as valves or instruments which may have numerous tag numbers associated with it.

The language of all documentation shall be in the English language. The units of measure shall be metric. The Contractor retains project design calculations and information for the entire life cycle of the plant and provides these to the Employer on prior written notice at any time notwithstanding the expiry or termination of the contract.

3.7.4. Engineering Change Management

All Design change management shall be performed in accordance with the latest revision of the Eskom Project Change Management Procedure (240-53114026) and the Employer shall ensure that the Contractor is provided with the latest revisions of this procedure. Any uncertainty regarding this procedure shall be clarified with the Employer and clarification updates should be reflected in updated versions of this procedure.

3.8. Testing Requirements

The Works shall undergo Factory Acceptance Testing (IEC 62381 FAT Procedure) in accordance with the requirements and procedures specified in the Employer's Requirements and the requirements that are specified by the Contractor in his Tender. The Contractor shall submit his proposed requirements for all the tests to be conducted to the Contract Manager and Engineer's representative for acceptance. These requirements shall be developed to demonstrate that the Works meet the requirements stated in this document. As a minimum Pressure Equipment Regulations must be adhered to. The test certificate including the performance tests shall be issued and shall be included in the data book.

3.9. Training Requirements

The Contractor shall provide training on the permanent works to operating, maintenance and engineering personnel. Training provided by the Contractor shall be practical, hands-on and directly applicable to the Permanent Works. The training must take place in South Africa. The person responsible for presenting the training is trained, competent and certified by the OEM. General training based on similar works is not acceptable.

The Contractor shall provide all course material including manuals. The course material shall be in English and shall include all third-party documentation. A copy of the training documentation shall be supplied for each trainee with an additional three master sets for the Employer's library and training department. This training shall include the knowledge and skills to enable individuals to adjust the internal parameters of the equipment to meet specific field conditions and to load firmware upgrades as and when required. The necessary configuration tools shall be provided to authorize staff to change these internal parameters. Trained and authorized personal will be issued the required passwords to effect the changes.

The dates for training shall be included and shown in the Contractor's programme. The supply of drafts, pre-print proofs and printed copies of training documentation shall be planned by the Contractor in such a way that this is complete before commissioning of the unit commences.

There must be cost line items for each discipline of training so that the scope and expectations are clear. Training may have to be provided in phases – upfront and as systems become available. Training manuals shall be continuously updated by the Contractor until the date of issue of the Performance Certificate for the whole of the Works.

4. Technical Requirements

4.1. Operating Philosophy

The operation of the plant shall be fully automatic with system start/stop initiated from the local control station which is connected to the controller of the PV plant. Local/Remote selection will be done at one location in the plant. The control system for the receiver filling and that of the generating plant shall be integrated to optimise the life of the cell stack and to ensure safe plant operation.

The hydrogen generating plant shall trip and purge automatically on low hydrogen purity (less than 99.5%). Under no circumstance will it be allowed that contamination in the hydrogen and oxygen lines exceeds 1.6% during the transient state, and less than 1% during steady state. The contamination on the hydrogen and oxygen lines will not be able to exceed 1% measure directly after the cell stacks.

The Eskom Hydrogen standard listed the following critical items for the safe operation of a hydrogen plant, and no plant shall operate without meeting these requirements:

- Oxygen content measurement of produced Hydrogen after the cells on atmospheric electrolysers.
- Hydrogen purity after the dryers including oxygen content (before bulk storage).
- Minimum flow through analysers is ensured.
- Hydrogen leak detection.
- Water seals (or flashback arrestors) on all vents.
- Approved area classification.
- Hydrogen fire detection.

- Hydrogen in oxygen measurement on the oxygen stream.
- Minimum quantity of inert gas connected to perform emergency purge on production.
- Plant Safety Regulations (PSR) integration

4.1.1. Receiver Operating Philosophy

The hydrogen will be stored in a pressure storage system that is equivalent to the electrolyser operating pressure minimum 27 bar, while the oxygen produced will be vented to atmosphere. The hydrogen from the pressure storage tank can be supplied to the end-uses that include a golf cart, fuel cells and appliances. The design should allow for future compression of hydrogen to 700 bar and storage in a high-pressure storage facility.

The metering station is responsible for reducing the pressure from the pressure storage to the required pressure for usage adjustable from 2.7 MPa to 1 MPa. At the metering station, the hydrogen as well as the oxygen purity is monitored to ensure that the correct purity of gas is being provided to the end user.

4.2. Mechanical and Process Requirements

4.2.1. Design Parameters

The renewable hydrogen facility shall be sized based on the renewable energy production capacity of the existing 400 kW Solar PV plant. The renewable energy will be stored in the Battery Energy Storage System to enable a continuous supply to the RHF. The steady state RE supply to the plant is anticipated to be 50 kW. The electrolyser(s) shall be designed for the least amount of cost to consume 50 kW; therefore, the configuration could be at maximum 1 x 50 kW electrolyser, with multiple cell stacks (minimum two) or smaller electrolysers. The design should allow for three (3) electrolyser connection points, although the additional electrolysers will not be constructed during the initial phase of the project. The hydrogen produced shall be at a minimum pressure of 27 bar with no compression and have minimum purity of 99.9% by volume and a dew point of 50^{o}C or better at 101.4 kPa. The hydrogen storage must be provided and shall not exceed 80 m^3 with a minimum operating pressure of 27 bar.

4.2.2. Piping System

The piping system shall comply with the requirements stated in the Eskom Specification for Hydrogen Systems 240-56227413. All welded joints shall be 100% x-rayed. The following requirements are additional to the Specification for Hydrogen Systems.

4.2.2.1. Hydrogen pipes

The piping shall be stainless steel as per Eskom Specification for Hydrogen Systems 240-56227413. The piping selection should consider stress, temperature, pressure failures and other conditions considered to characterise hydrogen embrittlement failures including hydrogen purity.

The hydrogen facility piping systems and hydrogen transportation pipes shall include safeguards in accordance with American Society of Mechanical Engineers (ASME) ASME B31.3 for the protection of the people and property against harmful consequences of piping failures. The pipework, valve and fittings shall be rated at 1.5 times the maximum operating pressure as specified in the Hydrogen systems standard 240-56227413, section 3.14.1.

All the piping and components shall be labelled, tagged, and coded as per the American National Standards Institute (ANSI) and American Institute of Aeronautics and Astronautics (AIAA) ANSI/AIAA G-095-2004-Section 4.10 and the standards specified therein.

4.2.2.2. Pipe Supports

The design of piping support members shall account for all loads acting on such supports and the supports shall be of materials suitable for the service conditions. Pipe support locations shall be shown on all general arrangement and elevation drawings, along with each support mark or reference number.

4.2.2.3. Holding down and Foundation Bolts

Holding down of the pipes, where required shall be designed and fabricated from materials suitable to secure the plant item in its designed operating position under all operating and environmental conditions.

4.2.2.4. Bolts, Nuts, Washers, Studs and Threads

All bolts, nuts, washers and studs shall be sized and be of material satisfactory for the maximum and varying operating and environmental conditions. They shall comply with the requirements of South African National Standards (SANS) SANS 1700 and the relevant standards specified therein, unless otherwise specified in these requirements or on approved drawings.

4.2.2.5. Trenches and Covers

Piping between the containers shall be placed in a new trench. The trenches are to be covered with removable grating.

4.3. Control and Instrumentation Design

C&I design entails all components from the field measurements to the human machine interface in the control room that interprets it as usable process data. These include instruments, junction boxes, cabling and trunking, Supervisory Control and Data Acquisition (this should be a PLC based SCADA) and the operator Human Machine Interface (HMI). The onsite Control and Monitoring System (CMS) or SCADA will perform the data acquisition and monitoring of equipment function that includes:

- Electrical low voltage (LV) and Medium Voltage (MV) switchgear,

- Electrical Protection,
- Energy measurement and metering,
- Uninterruptible power supplies (UPS),
- Internal environmental parameters measurement of equipment cabinets,
- PV and BESS systems
- Fire detection system, and
- HVAC system

The plant design includes a control room with two operator stations. Under normal operating conditions, the plant operates automatically with minimum operator intervention.

4.3.1. Control Room Design (Layout)

The containerised control room is of a modern, ergonomic design and complies to international standards (ISO 11064: Ergonomic design of control centres), Eskom Guideline (240-56355541: C&I Computer and Equipment Rooms Civil and General Building Requirements Guideline) and engineering best practices. The equipment/server room caters for (but is not limited to) the following cabinets:

- CMS server cabinet (servers, thin clients, etc),
- CMS network cabinet (network switches, splice trays and patch panels),
- CMS UPS system cabinet,
- IT/IM network cabinet, and
- Network cabinet for Eskom approved gateway/ remote terminal unit (RTU).

4.3.2. Network Architecture

The network is single fault tolerant and forms the backbone CMS network to enable data communication between the field equipment and CMS servers through a PLC. Any fault in a single segment of the network should not cause data communication failure between the control room and the plant. The core network allows for duplex communication. The network is compatible with simple network management protocol version 3 (SNMP v3) and internet protocol version 6 (IPv6). The RHF plant contains the CMS network panel that connects the various plant subsystems and the following signals:

- All PV signals from the PV plant that are deemed essential,
- All energy storage information from the BESS facility located within the premises that are deemed essential, currently the charging power and percentage state of charge is monitored
- Electrical protection signals that include status display signals and control signals
- All information from the demineralised water treatment plant that is deemed essential to produce green hydrogen, and
- All other information that is deemed necessary for successful implementation and operation of the RHF.

The CMS network panel is installed inside the server room that forms part of the overall control room. Active cooling of the equipment is required. The panel interfaces to:

- Switchgear breakers and status indication relays (including intelligent electronic devices (IED)),
- Protection systems,
- UPSs,
- Fire Detection panel, and
- HVAC panel.

There is one pair of redundantly configured CMS servers and one pair of redundantly configured network switches that will be installed in the server room to store plant data, process plant data and present information to the operator via the HMI on the operator stations. It is preferred that a master slave redundant configuration is employed for the network switches and servers located at the server room. Each CMS server includes a plant information server which will store all plant production data for the lifespan of the plant. The plant is required to have two operators, therefore thin client computers will be required for the operators in the control room. A single CMS software application will be installed onto the CMS servers for control and monitoring of all plant equipment.

At an operational level, redundancy will be employed such that any failure of a server, thin client, or network switch should not result in loss of operating, monitoring and protection of the plant. A common network switch is installed in the network cabinet of the server room for interfacing to the following systems:

- Global Positioning System (GPS) based time synchronisation,
- Control building HVAC system,
- Server room UPS monitoring system,
- HVAC panel, and
- Network printer.

An Operational Technology firewall, webserver and virtual private network (VPN) gateway are required for highly secured and stable connectivity of the RHF plant to the internet. The Eskom Cyber Security, DMZ, IT/OT and third-party interface standards are to be complied with.

4.3.3. Electrical Interface

The electrical interface is as per section 4.5.3, applicable standards and good engineering practices shall apply. All protection status, start and stop, and power measurement (active, apparent and reactive power) signals are monitored and displayed through the SCADA PLC and HMI provided by the contractor.

4.3.4. Control and Monitoring System Servers

There will be one pair (2) of redundantly configured CMS servers. The servers are required to operate as primary-standby configuration. The standby server will continue full operation of the CMS if the primary server fails to operate “normally” as required. A high-speed watchdog interface will interconnect both servers to establish a dual redundant configuration. Each server machine of the redundant pair includes the following hardware:

- Redundant central processing units (CPUs),
- Redundant array of independent disks (RAID) configuration,
- Redundant power supplies with dual power input ports,
- 19” rack-mountable enclosers,
- Onboard memory (solid state) to continuously process and store all real time plant data for the lifespan of the plant, and
- Removable media storage such as digital versatile disk (DVD) writer and front accessible universal serial bus (USB ports).

The dual redundant CMS servers will accomplish multiple functions that includes:

- Hosting the latest Windows operating system,
- Hosting a single CMS application software for operating and monitoring of all plant equipment,
- Hosting antivirus software,
- Store all engineering logic and CMS network configuration settings,
- Processing of plant data via the redundant information servers and storage of data onto the CPU database,
- Communicating to the thin clients for plant operation and network configuration,
- Network configuration, logic development, mimic development, antivirus and software updates,
- Automatic copying of data from the CPU’s built-in historian onto the removable media at pre-configured intervals, and
- Saving information, backing up of data onto removable media, closing all running applications and shutting down the CPU in an automatic sequence after detecting the loss of input power to the UPS system.

The operating system and application software versions will be confirmed during tender clarifications.

4.3.5. Operator System Thin Clients

The requirements for the Operator System Thin Clients includes the following:

- The HMI Thin Clients are the end-user interfaces to the plant. The HMI thin clients are configured for the end users to access the applications running on the server using the login credentials (i.e. Username and password).
- Two HMI Thin clients will be installed in the PV plant Control Room for parallel redundancy. If one HMI Thin client is faulty, the redundant thin client is online and available for use to the end user.
- Five HMI Thin client licences will be provided for remote users to access the SCADA server from the network in line with all IT governance standards e.g. 32-373: Information Security – IT/OT and Third Party Remote Access Standard.

- The following services will be granted to the user groups based on the client to server login credentials:
  - Operating personnel – HMI application,
  - Maintenance personnel – HMI application, copying and backup capabilities and administration.
  - Engineering personnel – Full read and write access to all applications or services on the server.
- All HMI thin clients will operate simultaneously.
- The Microsoft Windows standard interface will be deactivated for operating personnel.

4.3.6. Thin Client Hardware

Each thin client will meet the following hardware requirements:

a. 1 x thin client terminal.
   · Capable of connecting 4 display monitors
b. 2 x 32” display monitors
   · 1440p LED
   · 16:9 aspect ratio
c. 1 x USB keyboard
d. 1 x USB mouse

The hardware of both HMI thin clients will not share the same power source. Both HMI thin clients will be supplied from independent power sources as far as possible. The HMI thin client's hardware will be installed on the operator desks in the Control Room. The layout of the HMI thin clients' hardware must be ergonomically friendly to the end users.

4.3.7. HMI Application Software

4.3.7.1. General

The general requirements for the HMI Application Software are:

- The HMI application will be the graphical user interface to the plant.
- Upon starting the HMI application, the following functionality will be granted to the end users based on the login credentials:
  - Operator personnel – Full monitoring and operating,
  - Maintenance personnel – Full monitoring, and system administration
  - Engineering personnel – Full monitoring operating and engineering.
- The functionality provided by the HMI will include, but is not limited to the following:
  - Operating functionality,
  - Indication,
  - Alarming,
  - Trending,
  - On-load plant performance information,
  - Event viewing (including operator action events),

- List of forced signals, and
- Access to historical operating data.

- All operator actions will be logged.
- Selection of any HMI graphic will not require more than two keystrokes.
- The archiving of analogue tags is at a resolution of 1 second and all other events at a resolution of 1 millisecond

4.3.7.2. Response Times

All hardware and software will be specified to achieve the following response times:

- The response times for command outputs (running time command for HMI up to signal change at the field device) must not exceed 2s.
- The response time for updating of variables in HMI displays (running time of signal from signal change on the field device to change of the appropriate variables on the video display) must not exceed 2s.
- The maximum time taken to completely populate an HMI graphic with dynamic data will not exceed 2s.
- The average time taken to completely populate any HMI graphic with dynamic data will be less than 1s.
- The maximum time taken to completely populate a trend with dynamic data will not exceed 3s.
- The average time taken to completely populate any trend with dynamic data will be less than 1,5s.

4.3.7.3. Graphical User Interface

The Graphical User Interface (GUI) requirements are:

- The HMI GUI conforms to proven and best industry practices for SCADA systems.
- The Human Machine Interface Design Requirements Standard (240-56355728) can be used as a guideline to adhere to the following:
    - Alphanumeric characters,
    - Numeric Data,
    - Abbreviations and acronyms,
    - Labels,
    - Icons and symbols,
    - Colours for HMI graphics,
    - Cursors,
    - HMI graphics,
    - Menus,
    - Windows, and
    - Errors.
- The GUI will display the following information as a minimum:
    - Main overview window:

    - Plant map window,
    - Plant control window (i.e., voltage, current, frequency, setpoints, etc.), Automatic/Manual control mode, Local (Plant operator) or remote (SO) Control selection and status,
    - Status of main MV/HV breakers/isolators,
    - Summary alarm list showing high priority and rationalised alarms,
    - Trend window,
    - Redundant hardware status, and
    - Selection of any graphic on the main overview window will take the user to a more detailed graphic of information for the selected window.
  - Plant Control Window:
    - Remote/Local control mode selection and indication, and
    - Automatic or manual mode selection and indication.
  - Plant Electrical Line Diagram Window:
    - Displays the entire electrical reticulation of the plant, and
    - Clicking on a specific switchgear, transformer, meter, etc opens the field device window displaying information relating to the devices, etc.
  - SCADA Network Line Diagram Window:
    - Displays the entire SCADA network of the plant, and
    - Clicking on a specific network device (e.g. network switches, Server, Control Systems) opens the device window displaying information relating to the devices, etc.
  - Auxiliary and Ancillary Services Windows:
    - Displays the indications of the uninterruptible power supplies,
    - Displays the indications of the Auxiliary power distribution boards,
    - Displays the indications of the equipment environmental condition monitoring systems,
    - Displays the indications of the fire detection and alarm systems, and
    - Displays the indications of the HVAC systems.
  - Alarms window:
    - Displays all alarms that require operator intervention,
    - Alarms are automatically ordered according to their priority, and
    - Clicking on an alarm provides an alarm response window.
  - Individual Alarm Response Window:
    - Displays the possible causes of the alarms,
    - Displays the mitigation actions to attend to the alarm,
    - Includes a facility to suppressor disable a nuisance alarm for a temporary period, and
    - Historical alarms over a defined calendar period must be available for display.
  - Trend Window:
    - Includes real time trending of user selectable parameters,
    - Includes historical trends of user selectable parameters over a defined calendar period, and

- Each parameter must be clearly distinguishable in colour from the other parameters.

4.3.8. Field Devices

4.3.8.1. Requirements For Field Instrumentation

All pressure, temperature flow and level measurements are installed in line with the guidelines listed below, OEM's recommendations and good engineering practices:

- Temperature measurement system installation standard (240-56355888).
- Pressure measurement system installation standard (240-56355843).
- Field instrument installation standard for junction boxes and cable termination (240-56355815).
- Field equipment installation standard (240-56355754).
- The level of redundancy of the field installation is such that it is equal or better to the availability of the mechanical plant. The Safety Integrity Level (SIL) rating of all field measurements is such that it matches or is better than the specified mechanical design reliability figures.

In addition to the requirements of the abovementioned standards, the field equipment installed shall satisfy the following criteria:

- All field equipment operates over an ambient temperature range of: -10°C to 70°C.
- All field equipment is installed in a suitable location ensuring that it operates in an environment within the parameters stipulated by the manufacturer.
- Where harsh environmental conditions are not avoidable, the field equipment is designed for operation in that environment must be used.
- All field equipment is suitable for use in the zone in which it is installed. The zone classifications are as per SANS 10108 (5th edition 2005)
- All field equipment excluding junction/splitter boxes and their electrical connections are rated IP 65 or better.
- Junction/splitter boxes and their electrical connections are rated IP 66 or better.
- All IP ratings are as per SANS 60529.
- All field equipment is Ex rated for zone 1 operation

The instrumentation provided is standardised to the maximum extent possible

4.3.8.2. Requirements For Actuators

All actuators used for the RHF are electrical and fulfil the following requirements for actuators:

- The correct sizing, adaptability and suitability of all actuators are provided as part of the works.
- All actuators provided meet the requirements of the valves and dampers that they operate.

- Actuators are rated for the following duty classifications as per specification International Electrotechnical Commission (IEC) IEC 60034-1 (11th Edition 2004/04):
    - Short - time duty (S2-15min).
    - Intermittent duty (S4-25% ED); up to 1200 starts per hour; no. of starts depending on actuator size and output speed.
- Position transmitters of the two-wire type for the actuators are provided.
- All flanges and gearboxes from the actuator to the damper shaft or valve spindle are provided.
- Dimensions of the shafts and technical details such as turning direction, multi-turn, quarter turn, standard linear turn (not modified multi-turn) is determined during the detailed engineering phase.
- Direct mounted flanged type actuators are used for binary dampers with a keyed adaptive coupling (damper shaft/actuator shaft).
- The actuator is secured on a mounting which is included as part of the works.
- The weight of the actuator does not compromise the valve & pipe structure on which it is mounted.
- The design and sizing of actuators considers the duty cycle for the plant operation.
- Actuators are designed and selected such that no overheating occurs under worst-case conditions.
- The environmental conditions are considered. Where harsh environmental conditions exist, only actuators designed to operate in such environments must be used.
- All special tools (other than the normal hand tools) are provided by the Contractor at Completion.
- All electrical actuators conform to the following requirements as a minimum:
    - All actuator motors run with the correct rotation for the required direction irrespective of the connection sequence of the power supply.
    - To ensure the integrity of the enclosure, setting of limits and configuration of the indication contacts is carried out without removal of any covers.
    - The actuator incorporates local controls for open, close, and stop and a local/stop/remote mode selector.
    - This mode selector is lockable in any of the following positions:
        - local control
        - stop (no electrical operation)
        - remote
    - All electrically driven modulating actuators provided have integrated switchgear and thermal overload protection.
    - Thyristor based integrated switchgear is provided for all electric power actuators.
    - For analogue controlled electric actuators, an analogue 4-20mA command signal is employed for positioning the valve/damper.
    - Control actuators that operate on a high duty cycle must be rated for high duty operation.
    - Standardisation is achieved by selecting the minimum number of actuators that can cover all the load requirements for the entire plant.

- The internal limit switches on the actuators must be micro switches.

4.3.8.3. Hydrogen and Oxygen Analysers

The Hydrogen and Oxygen analysers requirements include:

- All analysers have a local display.
- All analysers can be configured either through local push buttons on the analysers or remotely through the operator workstations.
- All the engineering tools for programming and configuring the analysers are provided.
- All analysers have the following parameters available for configuration:
- High and low measuring range,
- High and low display range,
- Engineering units,
- Temperature at measurement cell (where applicable),
- Offset adjustment on temperature measurement (where applicable),
- Offset adjustment on measured value, and
- Indication of measurement device health.
- The output signal of all the analysers is a load independent direct current 4 to 20 mA signal.
- The output signal is also a rising linear and falling linear signal.
- The enclosures provide clear visibility of the local displays of the enclosed analysers.
- All analyser installations are in line with the Hydrogen systems standard (240-56227413).
- All analysers are Ex rated for zone 1 operation

4.4. Electrical Design

The electrical configuration of the RHF plant shall be integrated with the existing 400 kW Solar Photo-Voltaic (PV) plant, the 2.2 MWh battery storage BESS plant and reticulation of the ERIC facility by complying to all the requirements, standards stipulated to ensure the safe and efficient operation of the plant. Where required for integrations with existing infrastructure, outages need to be scheduled well in advance (2 months at least for electrical), as it entails shutting down power to some critical other RTD services. Outages are to be minimised to be the bare minimum. The requirements include all the electrical and auxiliary equipment as it deemed necessary by the Project (also covered in various sections of the systems of the document). Unless otherwise stated all electrical equipment necessary for the safe and efficient working of the hydrogen plant shall be provided according to the Hydrogen System Standard 240-56227413.

4.4.1. Integration to NW Substation (PV Plant Infra-structure)

In order to integrate the electrical supply of the new RHF to the existing PV electrical infra-structure, the new RHF plant Contractor is to retrofit the MCCB inside the functional unit of the existing Essential Board (rated 400 V AC, Fault rating of 30kA) in the North West Substation. The Contractor will also install a new power cable from the retrofitted MCCB at 400V Essential Board at the current

North-West Substation to the new position of the RHF plant. Electrical Drawings of the existing infrastructure are provided in Appendix B.

4.4.2. Integration to BESS Infra-structure

The BESS system will load follow the PV plant and produce the power required by the RHF plant for the duration required and according to the load variations.

4.4.3. Installation at the New RHF Facility

The Contractor to fill in 240-115583001 LV Switchgear Technical Schedule A&B and submit prior the detail design of the system.

The LV Switchgear and Controlgear Assembly shall comply to the Eskom standard 240-56227516 LV Switchgear Control Gear Assembly Associated Equipment for Voltage –1000V and 1500 V Standard.

Where cascading of the Moulded Case Circuit Breakers (MCCB) with Miniature Circuit Breakers (MCB), proper selection of protection curves to be evaluated and implemented.
The MCCBs to be used in the LV Switchgear and Controlgear Assembly shall be motorized to allow for remote closing and tripping.

All signals both control and indications to be wired to the SCADA system. The Contractor to fill in 240-115583001 LV Switchgear Technical Schedule A&B and submit prior the detail design of the system.

4.4.4. Cabling Requirements

Cabling, racking, routing and cable terminations to be done in accordance with the standard 240-56227443 Requirements for Control and Power Cables for Power Stations Standard and SANS 10142-1 The wiring of Premises Part 1 Low Voltage Installations.

4.4.5. Protection Requirements

Protection shall be in accordance with 240-56357424 MV and LV Switchgear Protection Settings Standard.

4.4.6. Power Demand Monitoring and Metering

The monitoring the power consumption from the renewable energy in accordance with the standard 240-56364444: Standard Minimum requirements for Metering of Electrical Energy and Demand. The contractor will assess all point of measurements and demand according to the existing infra-structure of PV and BESS system drawings provided with the tender documents.

4.4.7. Design Operating Philosophy

Contractor to keep abreast of changes happening in the projects pertaining to the current renewable infrastructure (PV and BESS) to ensure the electrical design aligns to all the affected changes. The electrical design shall be capable to integrate to the current and future modification of the current renewable infrastructure.

4.4.8. Stand-by and DC Requirements

Unless otherwise specified, auxiliary equipment shall be supplied with power through the substation alternating current (AC) and direct current (DC) supply routed from the AC & DC distribution board. The required power shall comply to the following applicable standards.

Equipment	Technical Standard
Nickel Cadmium Batteries	240-56360086, Stationary Vented Nickel Cadmium Batteries Standard
Vented Lead Acid Batteries	240-56360034, Stationary Vented Lead Acid Batteries Standard
Valve Regulated Lead Acid Batteries	240-51999453, Standard Specification for Valve-Regulated Lead Acid Cells
Power Electronics	240-53114248, Thyristor and Switch Mode Chargers, AC/DC to DC/AC Converters and Inverter/Uninterruptible Power Supplies Standard

4.4.9. Earthing and Lightning

The Contractor shall design and install the earth mat for the new RHF plant in accordance with 240-56356396.

4.4.10. LV Motors

LV motors required by the new plant to be design and installed to suite all the requirements as per the standard 240-57617975.

4.4.11. Load Requirements

The estimated total power consumption of the RHF plant is 130kW, however, the Contractor shall calculate the total power consumption and if the power consumption exceeds the estimated 130kW, the Contractor shall notify the Employer.

4.4.12. Small Power and lighting Requirements

The contractor shall design the lighting according to the 240-55714363 Coal Fired Stations Lighting and small Power Installation Standard.

The Contractor shall fill in Technical Schedule A&B and Appendix C of the 240-5571436 Standard in line with the VDSS and submit to the Employer to evaluate compliance prior to completion of the detailed design.

4.5. Civil and Structural Requirements Scope

4.5.1. Plant Layout

The Contractor develops a concept layout for acceptance by the Project Manager. The layout consists of all plant, foundation and integrations of the various services required. The Contractor considers the drainage requirements, daily operations and maintenance of the ERIC facility while developing the layout. Where applicable, the Contractor conducts Ground Penetration Radar (GPR) Scans to detect possible underground services and structures, to avoid clashes and to allow for connecting to existing services if needed.

4.5.2. Civil Engineering

The plant is considered temporary with a lifespan of approximately 15 years. The Contractor appoints a Professional Engineer with the required experience to design the required foundations for the plant, possible modifications to existing structures and civil infrastructure, as well as ensure the site has adequate drainage and develop the required temporary road network to access and maintain the plant.

The Contractor designs and installs a removable shelter above the C&I Control Room container with adequate gas venting and the ability to dismantle in the event that the end-user changes the container.

The Contractor encloses the site with a perimeter fence and allows for adequate access gates in line with the daily operations and maintenance requirements of the plant.

All design works are to be in accordance with the Eskom Standard 240-56364545 - Structural Design and Engineering Standard.

All designs produced are reviewed for acceptance from the Employer as per the Eskom design review procedure 240-53113685. Acceptance of the design by the Employer does not release the Contractor from design liability.

4.6. Construction Criteria

During construction the contractor must comply with:

- The contractor is responsible for the design, engineering, manufacture, quality control, procurement, handling, shipment and transport to/from site, storage, offloading, construction and erection, finishing, installation, commissioning, testing, optimisation and handover of equipment, tools, and materials for the works.
- The Contractor shall ensure compliance to SACPCMP (Act 48 of 2000)
- The Contractor constructs and erects the works in accordance with the Contractor's accepted design and takes cognisance of SANS 2001 and SANS 10400.
- All works are designed for constructability, reliability, and maintainability.
- The Contractor designs and procures all construction material and equipment required to perform the works.
- The Contractor identifies and includes all items required to form a complete, reliable, fit for purpose operating works, which complies with the requirements as stipulated in this Works Information.
- The Contractor provides all engineering calculations, drawings (hard and soft copy) models, inspection/quality reports, construction records, commissioning test reports, and other documentation as required by the scope of works.
- The Contractor provides dimensioned general arrangement drawings of the designed remedial works and detailed drawings of all components of the works, sufficiently detailed for the preparation of maintenance and operating procedures.
- The Contractor supplies drawings and documentation as specified in the Works Information. This includes, but is not limited to, General Arrangement (GA) drawings, fabrication drawings, construction drawings, as built drawings, maintenance and operating manuals for the fabrication and installation of the works.
- The Contractor's appointed Professional Engineer provides technical oversight during fabrication and construction.
- Other Plant and Materials or items associated with this works is utilised with prior approval from the Project Manager.
- The Contractor performs Factory Acceptance Testing (FAT) and Site Acceptance Testing (SAT) of the Plant and Materials.
- The Contractor designs and provides all falsework and formwork and any other necessary temporary works for the safe execution of the works.

4.7. Fire Protection

4.7.1. Fire Protection / Detection Assessment

A Fire Protection / Detection Assessment shall be done for the complete plant that is being provided. The assessment shall follow the requirements as set out in the Eskom Fire Protection / Detection Assessment standard 240-54937439. This assessment can also be presented in the form of a Fire Risk Evaluation showing how the fire system measures provided as part of the plant provides for risk mitigation and control measures.

A fire risk evaluation shall be performed by the Contractor; the report shall be submitted to the Engineer for approval as part of the detailed design process. The evaluation should result in a list of recommended fire prevention and protection features to be provided, based on acceptable means for the control of, ignition sources, fire and any hazards. The fire protection provided should be determined through an analysis of local conditions of hazards within the plant, exposure to other properties, the effectiveness of plant fire brigades, time of response and portable effectiveness of fire departments.

The provided fire risk management should focus on inherent process safety of the facility and as far as practically possible passive fire protection measures.

4.7.2. ERIC Site Existing Fire Protection and Fire Detection

4.7.2.1. Fire Protection System

The existing fire protection system on site is supported by a fire water tank fed by the municipal mains and a fire water pumping facility feeding fire water onto the ERIC premises. Technical specifications of this facility are as follows:

- Fire water steel panel tank volume – 144m3
- Pumping of fire water on site is supported as follows:
    - 1 x Jockey pump providing system pressure.
    - 1 x Main Electrical fire water pump rated at 124m3/h @ 69H.
    - 1 x Main Diesel fire water pump rated at 124m3/h @ 69H.

The fire protection hydrants provided on site are fed from a 150NB main pipeline.

4.7.2.2. Fire Detection System

The site is equipped with an existing Ziton ZP3 fire detection system. The Fire Detection/Protection Assessment executed by the Contractor shall investigate expandability of the existing fire detection system to cater for the proposed fire detection at the Hydrogen plant. Due to the volatile nature of Hydrogen, pre-warning such as Hydrogen leak and accumulation detection is preferred above smoke and/or flame detection.

By virtue of the DEOL (Department of Employment and Labour) mandate to SAQCC, any person designing, installing, commissioning, or maintaining Fire Detection Systems needs to be registered with SAQCC Fire according to SAQCC Fire rules and levels. Furthermore, contractors shall have an established installation base within South Africa.

All equipment and materials offered shall be locally supported by Original Equipment Manufacturers (OEM) or their officially appointed agents to ensure proper support and service.

All miscellaneous equipment shall be EN 54 certified. This includes cabling, trunking, conduits, cable trays, fixing hardware, general wiring, network equipment and fibre optics.

4.7.3. Contractors Scope for Fire System

The contractor must ensure that the following criteria are met.

- Perform a Fire Protection / Detection Assessment as per the Eskom Fire Protection / Detection Assessment Standard.
- Fire Protection and Fire Detection systems provided as part of the solution must comply with the requirements as set out in the Eskom Fire Protection and Eskom Fire Detection Design Standards.
- The Fire Protection / Detection Assessment with suggested fire systems as part of the system being provided must be accepted by the Employer.
    a. Passive fire protection (spatial separation, fire walls, bunding, drainage etc) should be incorporated as part of the design as far as possible negating requirements for active systems.
    b. Manual fire protection (hydrants, hose reels, fire extinguishers) must be supplied in and around the contracted facility as determined by the Fire Protection / Detection Assessment. Water supply for hose reels and hydrants will be connected to the site existing fire water supply.
    c. Fire Protection and Fire Detection Systems must integrate with existing infrastructure on ERIC site.
- All required safety signs must also be supplied as part of this scope. Safety signs must be compliant to SANS as per Eskom Standard requirements.

4.8. Spares and Maintenance Requirements

The EPC contractor shall take the maintenance philosophy into consideration in the final selection. A detailed maintenance programme for a 15 year life span shall be compiled. It shall consist of the component list, model numbers and technical description including details of critical spares. Routine maintenance of the plant equipment shall be required at 6 months intervals for minor maintenance and yearly for major maintenance interventions.

4.9. Technical Risk Assessments

The contractor shall evaluate project risks and provide a risk register and baseline risk assessment.

4.9.1. HAZOP Studies

The Contractor shall carry out formal Hazard and Operability (Hazop) Studies. These studies shall be done in accordance with the requirements as laid down in the Eskom Hazop Guideline: 240-49230111.

4.9.2. FMECA (Failure Mode Effects and Criticality Analysis)

The Contractor shall carry out formal Failure Mode Effects and Criticality Analysis (FMECA). These studies shall be done in accordance with the requirements as laid down in the Eskom FMECA guideline: 240-49230046.

4.9.3. HAZLOC

The contractor shall carry out formal HAZLOC (Hazardous Locations) Study according to the following Standard: 240-56536505. It is the contractor's responsibility to ensure that all electrical and instrumentation equipment on the hydrogen plant comply with relevant hazardous locations South African National Standards referred to on 240-56536505.

5. Acceptance

This document has been seen and accepted by:

Name	Designation
Manie van Staden	Hydrogen Specialist
Bathandwa Cobo	Research Manager
Motlalepule Dlamini	Gas & Renewable COE Manager
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6. Revisions

Date	Rev.	Compiler	Remarks
March 2024	1	Chantelle Moll	Develop Works Information for RHF design
February 2025	2	Chantelle Moll	Update Technical specification to be used as the scope of work for procurement. Change the title of the document.
March 2026	3	Chantelle Moll	Update document to clarify statements that may be miss understood by the market.

7. Development Team

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

- Jeanie Pistorius
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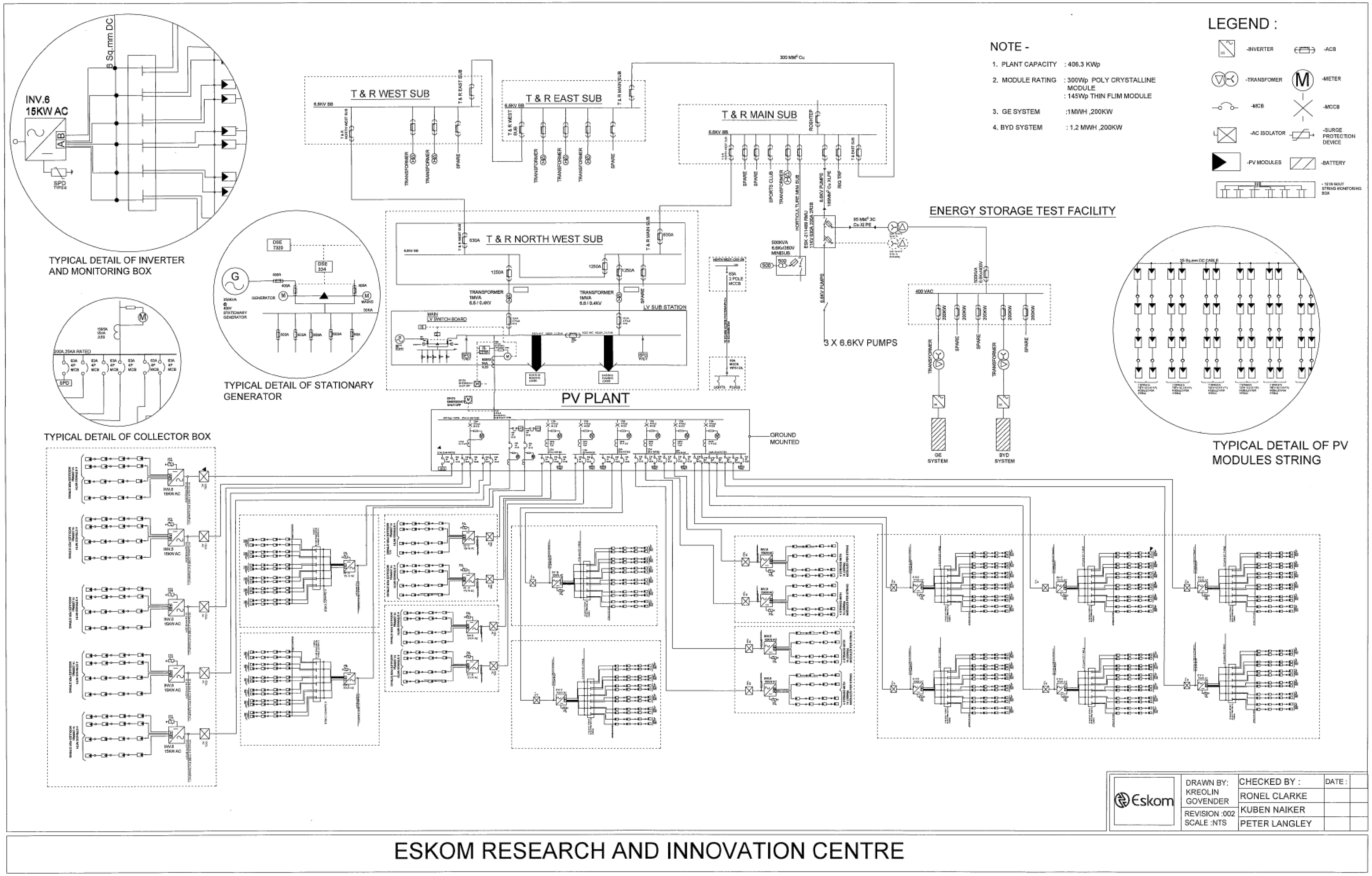
8. Acknowledgements

N/A

Appendix A: Typical Metering Panel

Appendix B: Electrical Drawings of ERIC.



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