Republic of Rwanda
Ministry of Education

RTB | RWANDA TVET BOARD

RENHO501

HYDROPOWER PLANT OPERATION

Operate hydropower plant

Competence

RQF Level: 5

Learning Hours 80

Credits: 8

Sector: ENERGY

Trade: RENEWABLE ENERGY

Module Type: SPECIFIC

Curriculum: ENGREN5001- TVET Certificate V in Renewable Energy

2024/25

Issue Date: May 2024

Purpose statement	This module describes the skills, knowledge and attitude required to operate hydropower plant equipment. At the end of this module, learners will be able to Run the hydropower plant equipment, Control the output of hydropower plant equipment and Maintain hydropower plant equipment.
Learning assumed to be in place	Hydro turbine generator installation, Pneumatic and Hydraulic system installation, Hydropower plant auxiliaries installation, Electrical machine winding

Delivery modality

Training delivery		**100%**	**Assessment**		**Total 100%**
Theoretical content		30%		30%	50%
Practical work:					Group project and presentation
• Group project and presentation	40%				Individual project /Work
• Individual project /Work	30%	70%	Formative assessment	70%	
		Summative Assessment			50%

Elements of Competency and Performance Criteria

Elements of competency	**Performance criteria**
1. Perform operation and maintenance preliminary activities	1.1. Workplace is well prepared based on operation and maintenance activities
	1.2. Hydropower plant equipment parameters are properly checked based on hydropower plant status

	1.3. Hydropower plant equipment functionality is properly analyzed based on hydropower plant parameters
	1.4. Equipment parameters are effectively recorded based on the hydropower plant Equipment status
2. Run the hydropower plant equipment	2.1. Electronic system is well activated according to activation procedures
	2.2. Hydraulic/ Pneumatic equipment are well started according to instruction guide
	2.3. Mechanical equipment are well started according to instruction guide
3. Control the output of hydropower plant equipment	3.1. Electro mechanical parameters are accurately monitored according to equipment operation manual
	3.2. Functionality data are accurately recorded according to equipment parameters
	3.3. Hydropower plant is properly shut down according to sequence and operational status
	3.4. Report is properly elaborated in line with reporting types and template
4. Maintain hydropower plant equipment	4.1. Preventive maintenance is properly performed based on maintenance plan

	4.2. Corrective maintenance is properly performed based on fault identified
	4.3. Hydropower plant equipment are correctly tested based on equipment performance
	4.4. Maintenance report is properly elaborated according to maintenance activities

Knowledge, Skills, and Attitudes

Knowledge	Skills	Attitude
✓ Basic First Aid. ✓ Measurement and calculation. ✓ Basic electrical installation. ✓ Electrical measurement and instrumentation. ✓ Water leakage testing ✓ Electrical wires ✓ Electrical insulation ✓ Fundamentals of electricity ✓ Colour code ✓ Cable size ✓ Electrical appliances and tools ✓ Electrical protection ✓ Measurement and calculation ✓ Hydropower principles	✓ Problem-Solving Skills ✓ Proper use of tools and equipment. ✓ Measurement of electrical voltage and current ✓ Alignment techniques ✓ Troubleshooting techniques ✓ Documentation and reporting ✓ Installation of	✓ Polite

✓ Control systems and SCADA ✓ Electrical systems ✓ Power generation ✓ Electrical diagrams schematics ✓ Safety and environment regulation ✓ Electrical safety ✓ Understand and interpret SCADA ✓ Principle of water flow ✓ Hydraulic systems ✓ Water management ✓ Plant operation ✓ Interpret engineering drawings ✓ Flood control measurement ✓ Motor control system ✓ Pneumatic and hydraulic concept ✓ Communication and teamwork ✓ Troubleshooting ✓ Ethics and integrity ✓ Occupational health and safety. ✓ Basic First Aid. ✓ Basics of electricity ✓ Fundamental of electronics ✓ Basic electrical installation. ✓ Electrical measurement and instrumentation. ✓ Electrical wires ✓ Electrical insulation ✓ Fundamentals of electricity ✓ Cable size	pumps ✓ Computer skills ✓ Hydraulic and pneumatic skills ✓ Water Management skills. ✓ Maintenance and Troubleshooting skills ✓ Reporting skills ✓ Communication and ✓ Teamwork Skills ✓ Measurement with tape meter ✓ Electrical Continuity testing ✓ Proper use of tools and equipment. ✓ Measurement of electrical voltage and current ✓ Tightening the bolts and nuts ✓ Electrical wire Stripping ✓ Electrical wire	✓ Self-motivated ✓ Skill ful ✓ Decisive ✓ Punctual ✓ Humble ✓ Patient ✓ Responsible ✓ Flexible ✓ Observant ✓ Goal oriented ✓ Self-confident ✓ Attentive ✓ Cooperative ✓ Faithful ✓ Good common sense ✓ Customer focused ✓ Energetic ✓ Able to work independently ✓ Strong moral character ✓ Open-minded ✓ Organized ✓ Maintain health ✓ Positive work ethics ✓ Gender sensitivity ✓ Flexible ✓ Problem solver ✓ Strong desire to excel

✓ Electrical appliances and tools ✓ Electrical protection ✓ Measurement and calculation ✓ Electrical systems ✓ Electrical diagrams ✓ Electrical safety ✓ Bench work. ✓ Water leakage testing ✓ Pipe joining ✓ Hydropower principles ✓ Control systems and SCADA Power generation	connection ✓ Read drawings ✓ Joint metal pieces ✓ Mix ration ✓ Moisture testing ✓ Precision cutting ✓ Data recording ✓ Alignment techniques ✓ Troubleshooting techniques ✓ Documentation and reporting ✓ Electrical components testing ✓ Installation of pumps ✓ Computer skills ✓ Technical Knowledge skills ✓ Hydraulic and pneumatic skills ✓ Water Management skills ✓ Maintenance and Troubleshooting skills	

	✓ Internet Skills ✓ Reporting skills ✓ Communication and ✓ Teamwork Skills ✓ Problem-Solving Skills	

Learning outcomes	At the end of the module the learner will be able to: 1. Perform operation and maintenance preliminary activities 2. Run the Hydropower plant equipment 3. Control the output of Hydropower plant equipment 4. Maintain Hydropower plant equipment
Learning outcome 1: Perform operation and maintenance preliminary activities	**Learning hours: 10 hours**
Indicative content	
• **Preparation of workplace** ✓ Identification of operation activities ✓ Identification of maintenance activities ✓ Selection of tools, materials and equipment	

- ✓ Inspection of equipment
- ✓ Checking of tools

- **Checking of Hydropower plant equipment parameters**

  - ✓ Electrical parameters
    - Voltage
    - Power factor
    - Frequency
    - Power
    - Current
  - ✓ Mechanical parameters
    - Speed
    - Guide vane position
  - ✓ Pneumatic parameter
  - ✓ Hydraulic parameters
    - Pressure
    - Temperature
    - Oil status

- **Analysis of hydropower plant equipment functionality**

  - ✓ Working conditions of Pneumatic equipment
  - ✓ Working conditions of Electrical equipment
  - ✓ Working conditions of Hydraulic equipment
  - ✓ Working conditions of Electronic equipment

- **Recording of hydropower plant equipment parameters**
  - ✓ Electrical
  - ✓ Mechanical

Resources required for the learning outcome	
Equipment	Overhaul valves, security valves/inlet valves, bypass valves, gate valves, turbines, hydraulic governor, alternators, control and monitoring system, crane, sump pump, transformers, emergency generator multimeter, power meter, frequency meter, clamp meter, thermometer, pressure gauge, tachometer
Materials	Pipes, circuit breakers, air break switch
Tools	Plier, spanner, screw driver
Facilitation techniques	• Group discussion • Brainstorming • Practical exercises in group work • Individual Practical exercises
Formative assessment methods	• Written assessment • Oral questions • Performance assessment

Learning outcome 2: Run the hydropower plant equipment	Learning hours: 20hours
Indicative content	

- **Activating of electronic system**
  - ✓ Applying Activation procedures of electronic system
  - ✓ Activating Control system component
    - Monitoring and supervisory system component
    - Communication system component
    - Protection system component
- **Starting hydraulic/pneumatic system component**
  - ✓ Hydraulic components
    - Pump
    - Actuators
  - ✓ Pneumatic components
    - Compressor
    - Actuators
- **Starting of mechanical system component**
  - ✓ Control gates
  - ✓ Valves
    - Hydraulic valve
    - Bypass valve
    - Main inlet valve (MIV)
  - ✓ Turbine generator unit

Resources required for the indicative content	
Equipment	Overhaul valves, security valves/inlet valves, bypass valves, gate valves, turbines, hydraulic governor, alternators, control and monitoring system, crane, sump pump, transformers, emergency generator multimeter, power meter, frequency meter, clamp meter, thermometer, pressure gauge
Materials	Pipes, circuit breakers, air break switch
Tools	Plier, spanner, screw driver, log book, pen
Facilitation techniques	• Group discussion • Brainstorming • Practical exercises in group work • Individual Practical exercises
Formative assessment methods	• Written assessment • Oral questions • Performance assessment

Learning outcome 3: Control the output of hydropower plant equipment	Learning hours: 25 hours

Indicative content

- **Monitoring electromechanical equipment parameters**
  - ✓ Electrical equipment parameters
    - Power
    - Power factor
    - Voltage
    - Current
    - Frequency
  - ✓ Hydro mechanical equipment parameters
    - Flowrate
    - Temperature
    - Water level
    - Pressure
    - Oil status
- **Recording of functionality data**
  - ✓ Data recording methods
  - ✓ Analysis of recorded data
- **Shutting down of hydropower plant**
  - ✓ Shutdown sequence
  - ✓ Normal shutdown
  - ✓ Quick shutdown
  - ✓ Emergency shutdown
- **Elaborating operational report**
  - ✓ Types of technical report
  - ✓ Report contents
  - ✓ Report format structure
  - ✓ Reporting methods

Resources required for the indicative content	
Equipment	Overhaul valves, security valves/inlet valves, bypass valves, gate valves, turbines, hydraulic governor, alternators, control and monitoring system, crane, sump pump, transformers, emergency generator
Materials	Pipes, circuit breakers, air break switch
Tools	Plier, spanner, screw driver,
Facilitation techniques	• Group discussion • Brainstorming • Practical exercises in group work Individual Practical exercises
Formative assessment methods	• Written assessment • Oral questions Performance assessment

Learning outcome 4: Maintain hydropower plant equipment	Learning hours: 25 hours

Indicative content

- **Performing preventive maintenance**
  - ✓ Implementation of maintenance plan
    - Daily
    - Weekly
    - Monthly
    - Annually
  - ✓ Applying maintenance procedures
- **Performing corrective maintenance**
  - ✓ Identification of the fault and fault's root
  - ✓ Fault rectification
    - Electrical fault
    - Electronic fault
    - Hydraulic fault
    - Pneumatic fault
    - Mechanical fault
- **Testing of maintained equipment**
  - ✓ Applying types of testing
  - ✓ Testing instrument
  - ✓ Conducting equipment tests
    - Functionality
    - Performance
- **Elaborating maintenance report**
  - ✓ Types of technical report
  - ✓ Report contents
  - ✓ Report format structure
  - ✓ Reporting methods

Resources required for the indicative content

Equipment	overhaul valves, security valves/inlet valves, bypass valves, gate valves, turbines, hydraulic governor, alternators, control and monitoring system, crane, sump pump, transformers, emergency generator, multimeter

	Torpedo level, tape measure, safety shoes, Micrometer, First Aid Kit, Personal Protective Equipment, Spirit level, Barometric altimeter, Radio altimeter, laser altimeter, GPS Altimeter watch, Buckets,
Materials	Pipes, circuit breakers, air break switch
Tools	Plier, spanner, screw driver,
Facilitation techniques	• Group discussion • Brainstorming • Practical exercises in group work Individual Practical exercises
Formative assessment methods	• Written assessment • Oral questions Performance assessment

Integrated/Summative assessment (For specific module)

MURAMBA HPP is 2MW Hydropower plant with two units (A,B) located in RUTSIRO district. Recently, one of operation and maintenance team member resigned and the company needs to recruit a technician to replace him/her and will be assigned for hydropower plant operation and maintenance tasks. During his/her operation duties, he/she faced a problem of unit A trip, as one of operation and maintenance technician, you are asked to restore the tripped unit within 10 hours by performing the following tasks:

- Troubleshoot the hydropower plant
- Maintain the defected equipment
- Re-operate the maintained hydropower plant equipment
- Elaborate the reports of the tasks above

Tools, materials and equipment are provided.

Tools	Pliers, spanners, screw drivers, hammer, user manual, Wrench, Allen-Keys Set, electronics toolkit
Equipment	PPE, Multimeter, work talk, Insulation Resistance Tester, Phase Rotational Tester, Tachometer, Earth Resistance Tester, Leak Detector
Materials/ Consumables	Insulation tape, bolts, nuts, screws wires, cables, grease, lubricants,

Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator	Observation		Marks allocation
			Yes	No	
1: perform operation and maintenance preliminary activities (20%)	1.1. Workplace is well prepared based on operation and maintenance activities	Tools are selected			**1**
		Materials are selected			**1**
		Equipment are selected			**2**
	1.2. Hydropower plant equipment parameters are properly checked based on hydropower plant status	Electrical parameters are checked			**1**
		Mechanical parameters are checked			**1**
		Pneumatic parameters are checked			**1**

		Hydraulic parameters are checked			**1**
	1.3. Hydropower plant equipment functionality are properly analysed based on hydropower plant parameters	Electrical parameters are analyzed			**2**
		Mechanical parameters are analyzed			**2**
		Pneumatic parameters are analyzed			**2**
		Hydraulic parameters are analyzed			**2**
	1.4. Equipment parameters are effectively recorded based on the hydropower plant Equipment status	Electrical parameters are recorded			**2**
		Eletronic parameters are recored			**1**
		Mechanical parameters are recorded			**1**
2: Run the hydropower plant equipment (20%)	2.1. Electronic system is well activated according to activation procedures	Activation procedures are respected			**3**
		Electronic system components are activated			**3**
	2.2. Hydraulic/ Pneumatic equipment are well started according to instruction guide	Pump is started			**2**
		Compressor is activated			**3**
		Actuators are activated			**2**
	2.3. Mechanical equipment are well started according to instruction guide	Control gates are opened			**3**
		Valves are opened			**2**
		Turbine generator unit is started			**2**
3: Control the output of hydropower plant equipment (30%)	3.1. Electro mechanical parameters are accurately monitored according to equipment operation manual	Flowrate is monitored			**2**
		Power and power factor are monitored			**2**
		Voltage are monitored			**1**
		Current are monitored			**1**
		Frequency are monitored			**1**
		Temperature is monitored			**1**

		water level is monitored			**1**
		Pressure and oil status are monitored			**2**
	3.2. Operational data are accurately recorded according to equipment parameters	Operational Electrical data are recorded			**2**
		Operational mechanical data are recorded			**2**
		Operational pneumatic data are recorded			**2**
		Operational hydraulic data are recorded			**2**
		Operational Electronics data are recorded			**2**
	3.3. Hydropower plant is properly shut down according to sequence and operational status	Shutdown sequence is respected			**3**
	3.4. Report is properly elaborated in line with reporting types and template	Report contents are indicated			**2**
		Report format structure is respected			**2**
		Reporting methods are respected			**2**
4. Maintain hydropower plant equipment **(30%)**	4.1.Preventive maintenance is properly performed based on maintenance plan	Maintenance plan is updated			**2**
		Maintenance procedures are respected			**2**
		Fault is identified			**2**
	4.2.Corrective maintenance is properly performed based on fault identified	Electrical faults are rectified			**2**
		Electronic faults are rectified			**2**
		hydraulic faults are rectified			**2**

		pneumatic faults are rectified			**3**
		Mechanical faults are rectified			**3**
	4.3. Hydropower plant equipment are correctly tested base on equipment performance	Electrical components are tested			**2**
		Electronics components are tested			**2**
		Mechanical components are tested			**2**
	4.4. Maintenance report is properly elaborated according to maintenance activities	Report is elaborated			**2**
		Report format structure is respected			**2**
		Report is submitted			**2**
Total marks					100
Percentage Weightage					100%
Minimum Passing line % (Aggregate): 70%					

References

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Glossary

- **Head**: The vertical distance between the water surface in the reservoir and the water surface at the turbine, influencing the potential energy available for power generation.

- **Flow Rate**: The volume of water passing through the turbine per unit of time, typically measured in cubic meters per second (m^3/s).

- **Capacity Factor**: The ratio of actual energy produced by the plant to the maximum possible energy it could produce if it operated at full capacity all the time.

- **Efficiency**: The ratio of the useful electrical energy output to the total mechanical energy input from the water.

- **Load Factor**: The ratio of the average load on the plant to its maximum capacity during a specific period.

- **Run-of-River**: A type of hydroelectric generation plant where the natural flow and elevation drop of a river are used to generate electricity without a large reservoir.

- **Peaking Power**: Power generated to meet peak demand periods, usually by adjusting the water flow to increase electricity production during high demand times.

- **Spillway**: A structure used to provide controlled release of water from the reservoir to prevent overflow and manage reservoir levels.

- **Intake Gate**: A gate that controls the flow of water from the reservoir into the penstock and towards the turbine.

- **Tailrace**: The channel that carries water away from the turbine after it has passed through, usually leading it back to the river or water source.

- **Grid Synchronization**: The process of matching the output of the hydropower plant with the electrical grid's frequency and voltage before connecting them.

- **Black Start Capability**: The ability of a hydropower plant to start generating electricity without relying on an external power supply, useful for grid recovery after a blackout.

- **Surge Chamber**: A chamber connected to the penstock to absorb pressure fluctuations and prevent water hammer effects in the system.

- **Penstock**: A large pipe that carries water from the reservoir to the turbines.

- **Transformer**: A device that changes the voltage of the electrical output from the generator for efficient transmission and distribution.

Author's Note Page

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