ELM370S - Electrical Machines 3

IoT-Enabled Gully Plug Rainwater Harvesting System

Cape Peninsula University of Technology | Department of Electrical, Electronics and Computer Engineering
Lecturer: Mr. G. Rose | Subject Coordinator: Prof. S. Krishnamurthy | 2026

Abstract

This report presents a scaled IoT-enabled gully plug rainwater harvesting prototype for ELM370S Electrical Machines 3. The artifact collects roof runoff, filters and routes water into linked storage tanks, monitors rainfall and tank conditions using ESP32-based sensing, and drives a DC pump through a protected switching stage. A 220 V to 12 V step-down transformer, rectification, voltage regulation, relay switching, and low-voltage sensor wiring connect the project directly to electrical machines, power conversion, automation, and safety. The report evaluates GA7: The engineer and the world, including critical awareness of sustainability and engineering impact on society, the economy, industrial practice, and the physical environment.

Project Objectives

- Collect roof runoff through gutter guards, a downspout filter/diverter, and linked storage tanks.
- Use a DC pump as the motor-driven machine element for water transfer and live demonstration.
- Use a 220 V to 12 V transformer, rectifier, filtering, and buck conversion to show safe low-voltage supply design.
- Use ESP32 control, sensor inputs, LCD feedback, and remote monitoring to improve on manual PWM-only designs.
- Address overflow, flooding, theft/tamper risk, local maintenance, cost, and community responsibility.

GA7 Study Guide Alignment Matrix

The subject guide requires critical awareness of sustainability and impact on the social, industrial, and physical environment. The assignment brief adds economy, safety, analysis, and evaluation. The matrix below maps those source points to project evidence.

Source point	Requirement	Project coverage
GA7 learning outcome	Demonstrate critical awareness of sustainability and the impact of engineering activity on the social, industrial, and	The report evaluates the rainwater system as a social water-access intervention, a small industrial automation system, and a
Study guide descriptor	Show knowledge and understanding of impact on society, economy, industrial and physical environment, addressed by	Cost tables, supplier discussion, safety controls, data plan, full-scale implementation, and risk analysis are used
Safety and sustainability range	Consider environmental, sustainability, and safety issues in a specific engineering project.	The design includes overflow control, first-flush/filtration, transformer isolation, fusing, enclosure protection, tamper detection, and
Rubric indicator 1	Consider cultural, disciplinary, and ethical perspectives when investigating engineering impact on society and	Outcome 1 covers user needs, water equity, affordability, local procurement, electrical/civil/environmental perspectives,
Rubric indicator 2	Consider impacts of engineering interventions, decisions, and technology on society and environment in historical and/or	Outcome 2 compares manual and IoT control, relates the project to Cape Town water restrictions and load-shedding, and
Rubric indicator 3	Identify societal and environmental challenges and possible solutions.	Outcome 3 and the risk table address water shortage, flooding, contamination, theft/tamper, load-shedding, sensor error,

Rubric indicator 4	Recognise individual and collective responsibility and evaluate the consequences of engineering activity.	Outcome 4 defines member accountability, group documentation, community ownership, safe operation, honest
Evidence requirement	Research and apply engineering knowledge to a project, draw conclusions from evidence, and record purpose,	The testing plan asks for measured transformer output, pump flow, tank level, rain-sensor response, alert logs,

Prototype Architecture

The system is divided into plumbing, control, power, sensing, and communication layers. Rainwater is captured at the roof edge, screened, passed through a first-flush/filter stage, and stored in three linked tanks. The controller reads rain and level conditions, then switches the pump, valves, indicators, and alarms.

Figure 1: Microcontroller-based prototype layout with ESP3

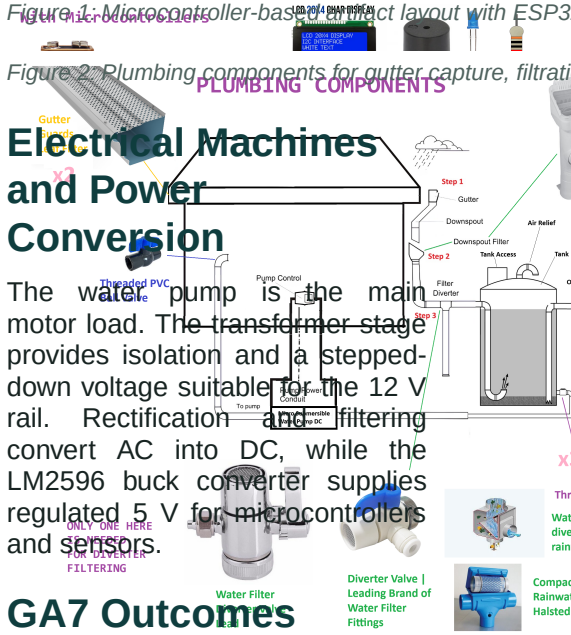


Figure 2: Plumbing components for gutter capture, filtrati

Electrical Machines and Power Conversion

The water pump is the main motor load. The transformer stage provides isolation and a stepped-down voltage suitable for the 12 V rail. Rectification and filtering convert AC into DC, while the LM2596 buck converter supplies regulated 5 V for microcontrollers and sensors.

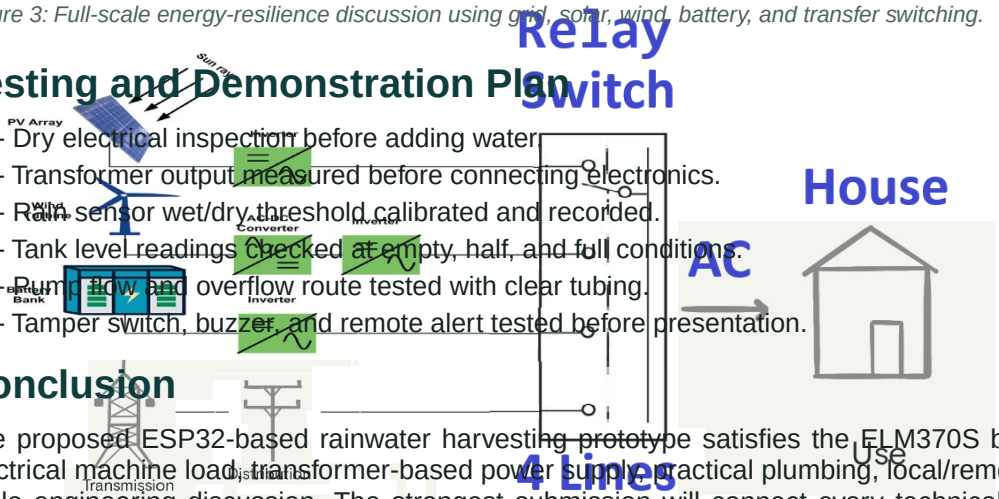
GA7 Outcomes

Outcome 1 considers cultural, ethical, disciplinary, and stakeholder perspectives. Outcome 2 evaluates historical and contemporary impacts of ESP32 automation, remote monitoring, cost, maintenance, and procurement on society, economy, industry, and the physical environment. Outcome 3 identifies flooding, contamination, theft, load-shedding, and mitigation. Outcome 4 focuses on safe engineering practice, community upkeep, member accountability, limitations, benefits, and consequences.

Cost Analysis

Category	Key items
Microcontroller and sensors	ESP32 board LCD, buzzer,
Power supply	Transformer, diodes, fuse
Enclosure and wiring	IP65 enclosu cable glands
Plumbing and model	Gutter guard pipes, fittings
Recommended prototype total	Option A with

Figure 3: Full-scale energy-resilience discussion using grid, solar, wind, battery, and transfer switching.



Testing and Demonstration Plan

- Dry electrical inspection before adding water.
- Transformer output measured before connecting electronics.
- Rain sensor wet/dry threshold calibrated and recorded.
- Tank level readings checked at empty, half, and full conditions.
- Pump flow and overflow route tested with clear tubing.
- Tamper switch, buzzer, and remote alert tested before presentation.

Conclusion

The proposed ESP32-based rainwater harvesting prototype satisfies the ELM370S brief by combining an electrical machine load, transformer-based power supply, practical plumbing, local/remote control, and a full-scale engineering discussion. The strongest submission will connect every technical feature to evidence: water flow, sensor data, cost, safety, overflow control, theft protection, community involvement, and the four GA7 outcomes.

References

- CPUT ELM370S Subject Guide, 2026.
- CPUT Assignment 1 / Project Brief 1, 2026.
- BET Project Report Guidelines, 2026.
- ELM370S Component List v2, 2026.
- SANS 10142-1 safety principles for electrical installation discussion.