Design and Analysis of a Renewable Energy Powered Reverse Osmosis Water System for Use in a Remote Location in Newfoundland

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Presentation Outline

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- System Architecture and Implementation
- Experimental Validation

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Background

- Water

Potable water has always been a critical source all over the world. Even though about 70% of the earth is covered by water, only 1% is accessible freshwater

Health Canada
The World Health Organization (WHO)
United States Environmental Protection Agency (EPA)

Table 1. Drinking water quality guidelines (in mg/L unless otherwise stated).

Compound	Health Canada (2022)	WHO (2022)	US EPA (2024)
Microbiological Parameters			
Escherichia coli (E. coli)	Nondetectable per 100 mL	Nondetectable per 100 mL	
Chemical and Physical Parameters			
Aluminum	2.9	0.2	NA
Arsenic	0.01 ALARA	0.01	0.01
Chromium	0.05	0.05	0.1
Copper	2	2	1.3
Fluoride	1.5	1.5	4
Manganese	0.12	0.5	0.05
Mercury	0.001	0.001	0.002
Nitrite	3 as nitrite; 1 as nitrite nitrogen	3	1.0
Haloacetic acids – Total (HAAs)	0.08	NA	0.060
Iron	AO: ≤ 0.3	NA	NA
Lead	**0.005 ALARA**	0.01	0.015
Colour	15 TCU	15 TCU	15 TCU
pH	7.0–10.5	6.5-8.5	6.5-8.5
Sulphate	AO: ≤ 500	NA	250
Total dissolved solids (TDS)	AO: ≤ 500	NA	500
Bromodichloromethane	0.016	0.060	0.08
Trihalomethanes3 (THMs)	0.1	0.1	0.08

Background

- Desalination

✓ Thermal : multi-stage flash distillation (MSF), multi-effect distillation (MED), and mechanical or thermal vapor compression (MVC) or (TVC).

✓ Membrane-based : Reverse osmosis (RO) and electrodialysis (ED)

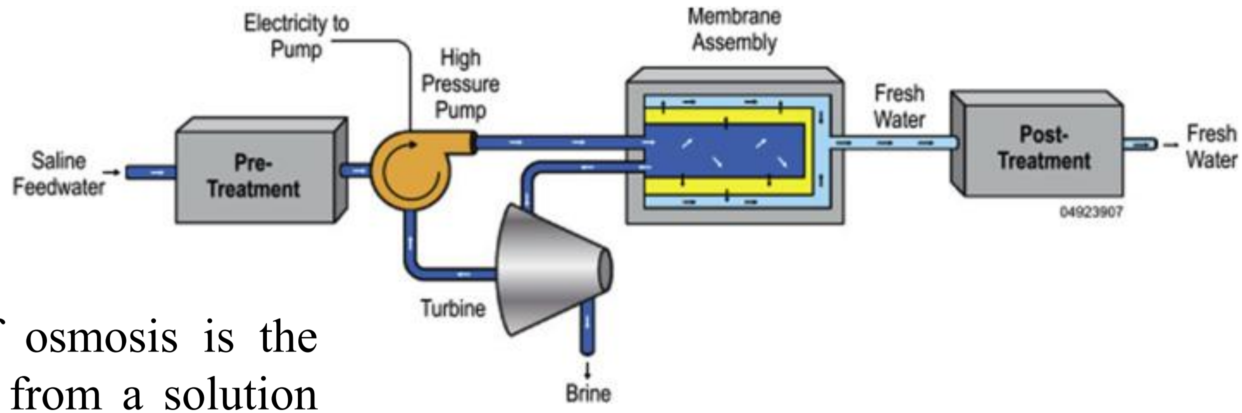

Figure 1. Schematic diagram of RO system.

The fundamental principle of osmosis is the migration of water molecules from a solution of lower concentration to one of higher concentration through a semi-permeable membrane.

Emissions resulting from the desalination process are predicted to reach billion tons of CO2 equivalents per year by 2050.

Literature Review

Table 2. Literature Review

Authors/year	Grid	PV	Wind	BAT	DG	RO	Other Load	Location	Analytical Tools or Methods	Feature
Novosel et al./2015		✓	✓			✓	✓	Jordan	Energy PLAN	Increased the share of intermittent renewables in the production of electricity up to 76% Reduction of CO_2 emissions and costs
Alsheghri A et al. /2015	✓	✓				✓		Dubai, UAE	RET Screen	Produced water = 0.225 $/m3. Reduce the emission of GHG by 1,035 CO2 84% reduced water production subsidies
Wu et al./2018		✓		✓	✓	✓	House Load	Khorasan, Iran	Tabu Search	NPC: 28,130 USD Produced water:1.59 to 2.39 USD/m3 COE: 0.3975 to 0.5975 USD/kWh
Kabir K et al. /2018		✓				✓		Sandwip, Bangladesh	HOMER & Toray	Produced water = 0.002$/litre system electricity cost =0.13$/kWh
Ghenai Helal et al. /2019	✓/-	✓		✓		✓	Agriculture Farm	Sharjah, UAE	Homer Pro	Grid-connected PV COE: (85$/MWh), Renewable fraction (67%), Greenhouse gas emissions (208 kg/MWh)
Mousavi/2021		✓		✓	✓/-	✓	House Load	Tehran, Iran	Homer Pro	With out DG: NPC: $10,245, COE: 0.31 $/kWh GHG emission-free CC dispatch strategy
Ajiwiguna T. et al./2022		✓		✓		✓		Wando Island, South Korea	Spyder-Python	Adding seasonal water storage tank The water production cost declined from 10.21 to 2.31 USD/m3 and from 36.96 to 3.06 USD/m3 for constant and variable demand
Dawoud M et al./2024		✓				✓		Egypt	GIS site selection	Cost of desalination = 0.55–0.63 USD/m3 Capital expenditure of capacity =760- 850 USD/m3

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Research Objective

- To design a reverse osmosis (RO) water treatment system sized to meet the daily water demand of the McCallum community.
- To design a hybrid PV–wind–diesel power system capable of reliably supplying the RO unit and other essential loads, considering local renewable resources and environmental conditions.
- To evaluate the techno-economic feasibility of the proposed hybrid system, focusing on cost of energy, fuel savings, and system sustainability.
- To analyze the system's dynamic performance under fluctuating loads and weather conditions using simulation tools.
- To develop and validate an offline SCADA-based monitoring and control system with bidirectional capability, optimized for remote deployment without internet connectivity.

Site Selection

- Water shortages

The Canadian Drought Monitor (CDM) - Canada's authoritative body for drought monitoring and reporting, McCallum is currently experiencing abnormally dry conditions.

Figure 2. Water management in McCallum.

- Water lead contamination

Recent samples from 2022 and 2023 revealed lead concentrations of 0.02 mg/L and 0.016 mg/L.

Figure 3. Water contamination in McCallum.

- Heavy reliance on diesel generators

These isolated communities face expensive electricity generation expenses due to fuel and maintenance costs. To alleviate this burden, approximately 75% of the cost is subsidized by others connected to the transmission grid.

Figure 4. Diesel generator in McCallum.

RO system can purify toxic heavy metals such as lead (Pb) over 99%.

Resources in Selected Site

Latitude: 47.6311
Longitude: -56.2292.

Figure 5. Selected site McCallum, Newfoundland and Labrador.

Average GHI : 3.17 kWh/m²/day

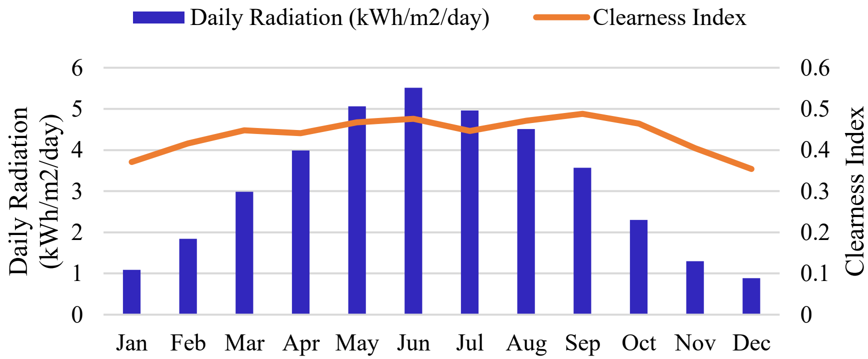

Figure 6. Average daily radiation and clearness index data.

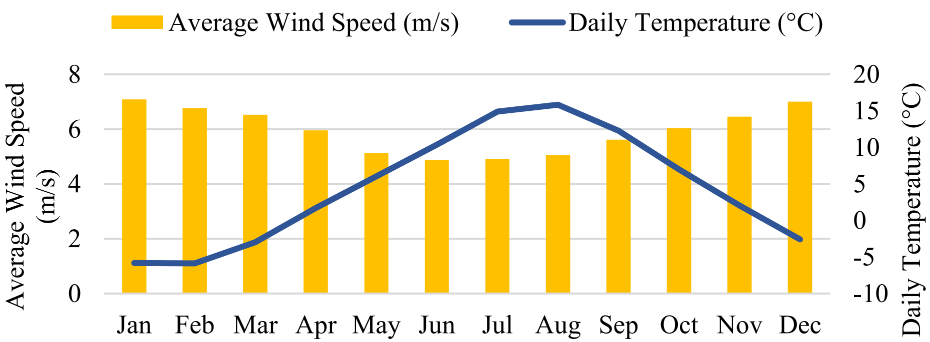

Figure 7. Average wind speed and daily temperature data.

Average wind speed: 5.9 m/s
at an elevation of 50 m

NASA Prediction of Worldwide Energy Resource (POWER) database

Electrical Load Analysis

Desalination methods : Membrane Desalination (**Reverse Osmosis**)

- Water demand per person: **223** liters.
- Population: **45**
- Total daily demand : **3000** GPD (considering 20% extra).
- The RO system and submersible pump operate **24/7** to prevent freezing and ensure continuous water supply.
- Total energy demand = **22.37** kWh/day

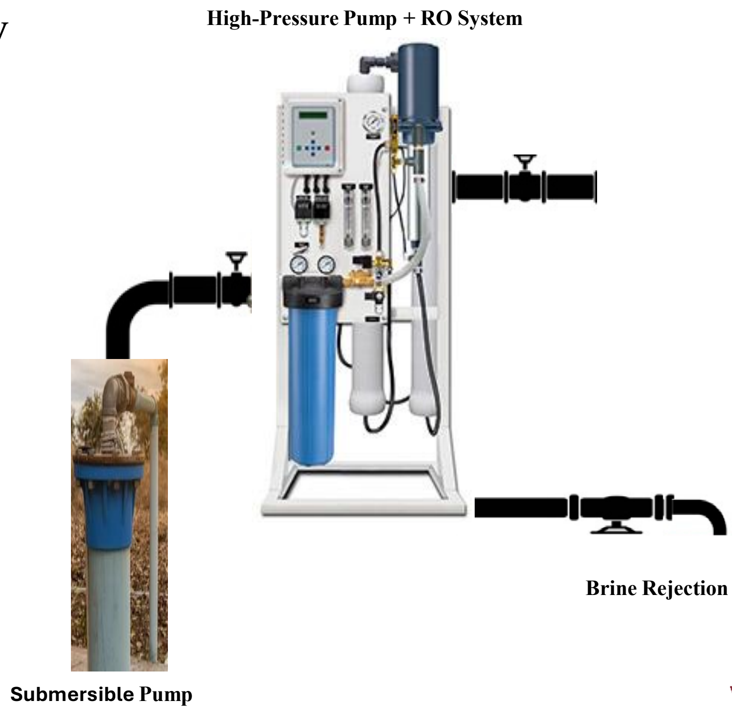

Figure 8 Water system configuration.

System Performance Analysis using HOMER Pro

Table 3. Capacity and Costs of Components.

Components	Capacity	Initial Cost	Replacement Cost	O&M Cost
PV Panel	0.300 kW	$500	$400	$5 /year
Wind Turbine	2 kW	$6,000	$4,500	$20/year
Battery	12V 170Ah	$446	$446	_
Converter	2.6 kW	$4,000	$4,000	_
Diesel generator	3 kW	$1350	$1350	$0. 3/op. hour

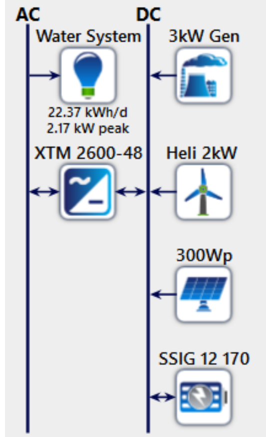

Figure 9. Schematic diagram of HES System.

Economic inputs:

- The total project lifespan 25
- The discount rate 8.25%
- Inflation rate 2.8%

An upwind 3-bladed WT with 18 m hub height and rated power of 2kW with an output voltage of 48 V DC

A 3 kW DC diesel generator with a 15000-hour lifetime

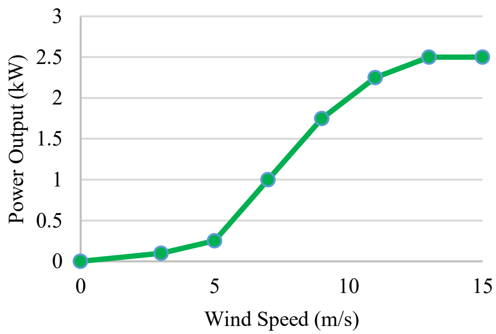

Figure 10. Wind turbine power curve.

PV module is a 72-cell Panasonic Mono crystalline with an STC power rating of 300 watts and 15.17%

A 12V-170Ah Lead Acid Trojan SSIG batteries with 80% efficiency

System Performance Analysis using HOMER Pro

- HES Components:

3.19 kW PV panels

2 kW wind turbine

3 kW diesel generator

32.3 kWh battery

Load following strategy

Table 4. Homer simulation results for different scenarios.

Parameters	Case I	Case II	Case III	Case IV	Case V	Case VI
PV (kW)	3.19	4.11		9.13	13.5	
Wind (kW)	2	2	2			
Generator (kW)	3		3	3		3
Converter (kW)	1.56	1.59	1.58	1.56	1.58	1.56
Battery (Qty)	16	24	24	20	28	
Dispatch Strategy	LF	CC	CC	LF	CC	CC
Total NPC	$44,382	$45,259	$64,176	$65,829	$69,392	$153,940
COE ($/kWh)	$0.397	$0.405	$0.575	$0.590	$0.621	$1.380
Unmet electric load (kWh/year)	0.71	1.1	0.429	0.692	0.772	0.612
Capacity shortage (kWh/year)	7.86	7.88	6.05	7.75	6.87	7.22
Excess electricity (%)	29	36	3.66	37.2	56.3	1.77
Renewable fraction (%)	98.8	100	73.8	95.6	100	0
Autonomy(hr)	27.7	41.6	41.6	34.6	48.5	0
Fuel (L/yr)	45.9	0	717	161	0	3738

- Optimized system

Net Present Cost (NPC): $44,382,

3.4 times lower than diesel-only system

System Performance Analysis using HOMER Pro

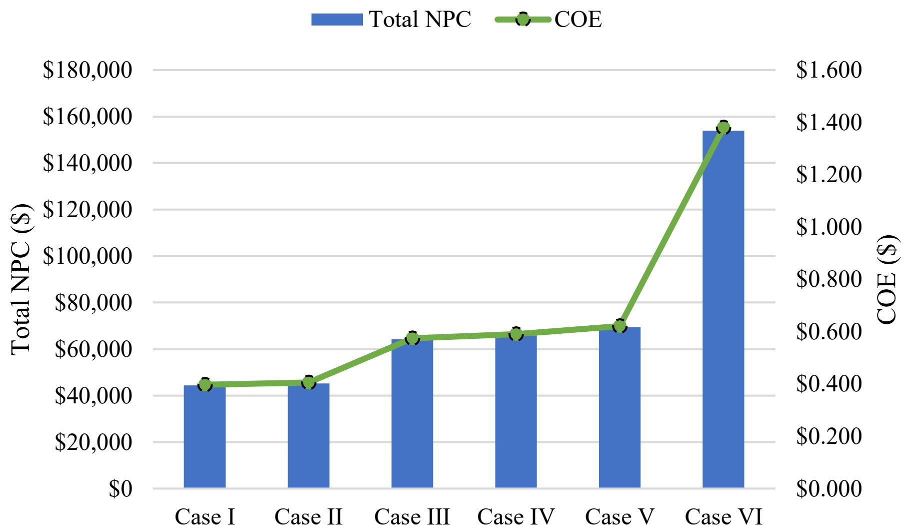

Figure 11. NPC and COE for different scenarios.

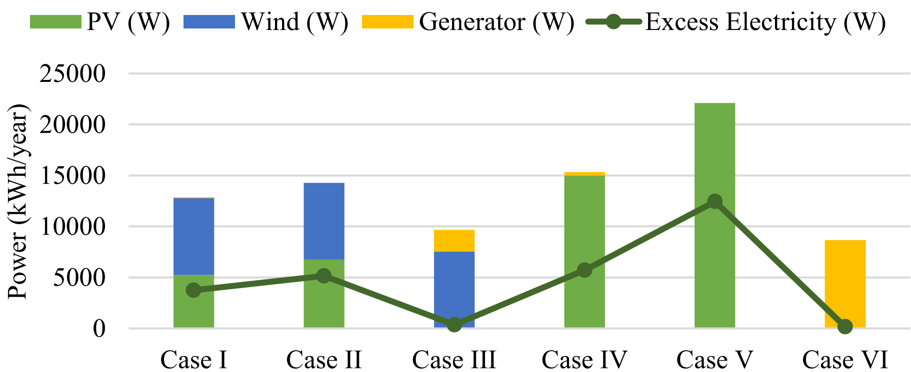

Figure 12. Total yearly electricity production for different scenarios.

System Performance Analysis using HOMER Pro

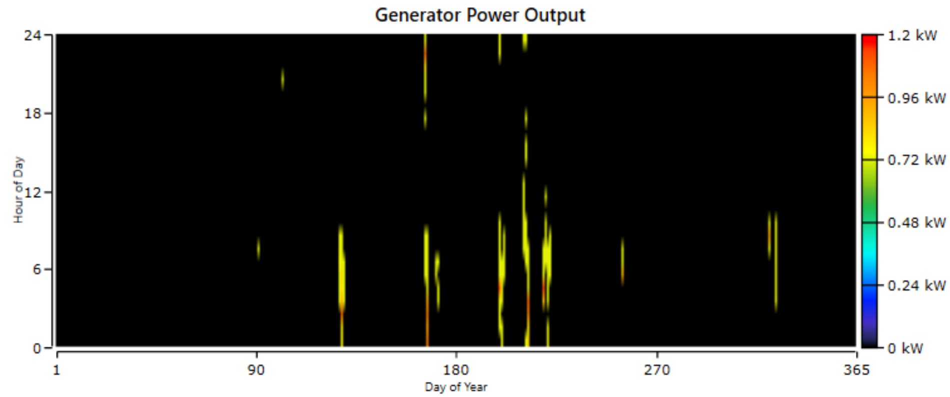

Figure 13. Hourly and monthly generator power output.

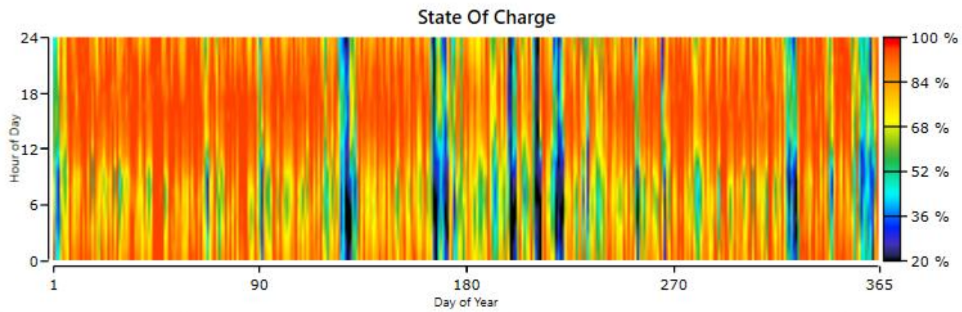

Figure 14. Hourly and monthly Battery state of the charge.

Results and Economic Analysis

Sensitivity analysis

- **Fuel Price**

The diesel price range of $1.66/L to $2.16/L in Canada that happened from 2022 to 2024.

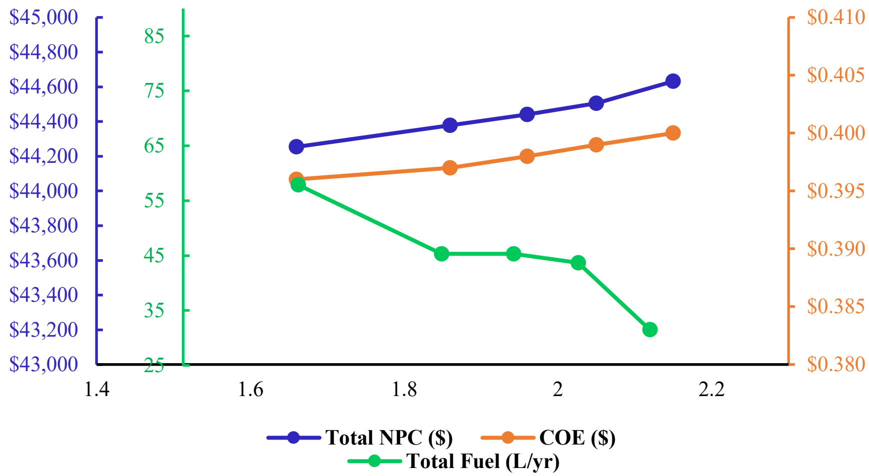

Figure 15. Sensitivity analysis for different fuel prices

Results and Economic Analysis

Sensitivity analysis

- **Annual Average Load**

The increasing the load from 22.37 to 25.4 kWh/day

while excess energy decreases from 29% to approximately 25%.

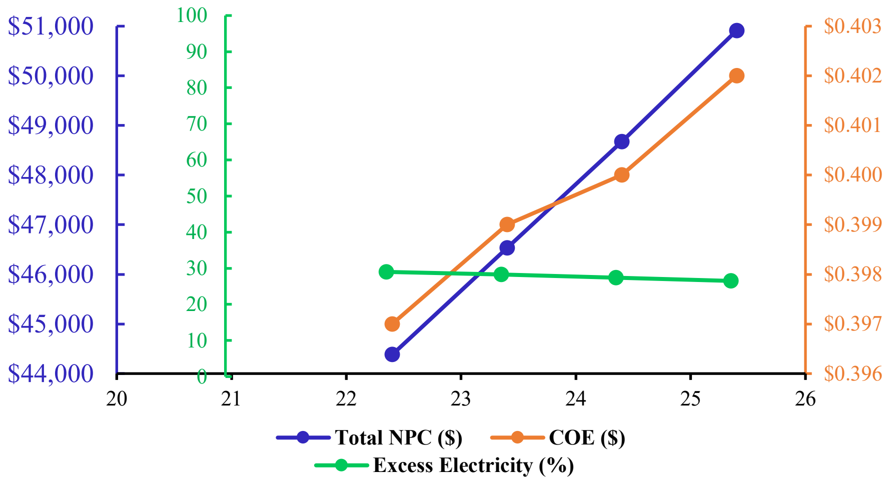

Figure 16. Sensitivity analysis for different annual average loads.

Dynamic simulation in Simulink/MATLAB

Table 5. Hybrid energy system details.

Component	Specification	Capacity
PV array	300Wp Panasonic	3.6 kW
Wind turbine	HAWT	2 kW
Diesel generator	DC	3 kW
Batteries	Lead Acid	12 v 680 Ah
Load 1(Resistive)	Lighting	0.3 kW
Load 2 (Inductive)	Asynchronous Machine 1	0.38 kW (0.5 hp)
Load 3 (Inductive)	Asynchronous Machine 2	0.56 kW (0.75 hp)

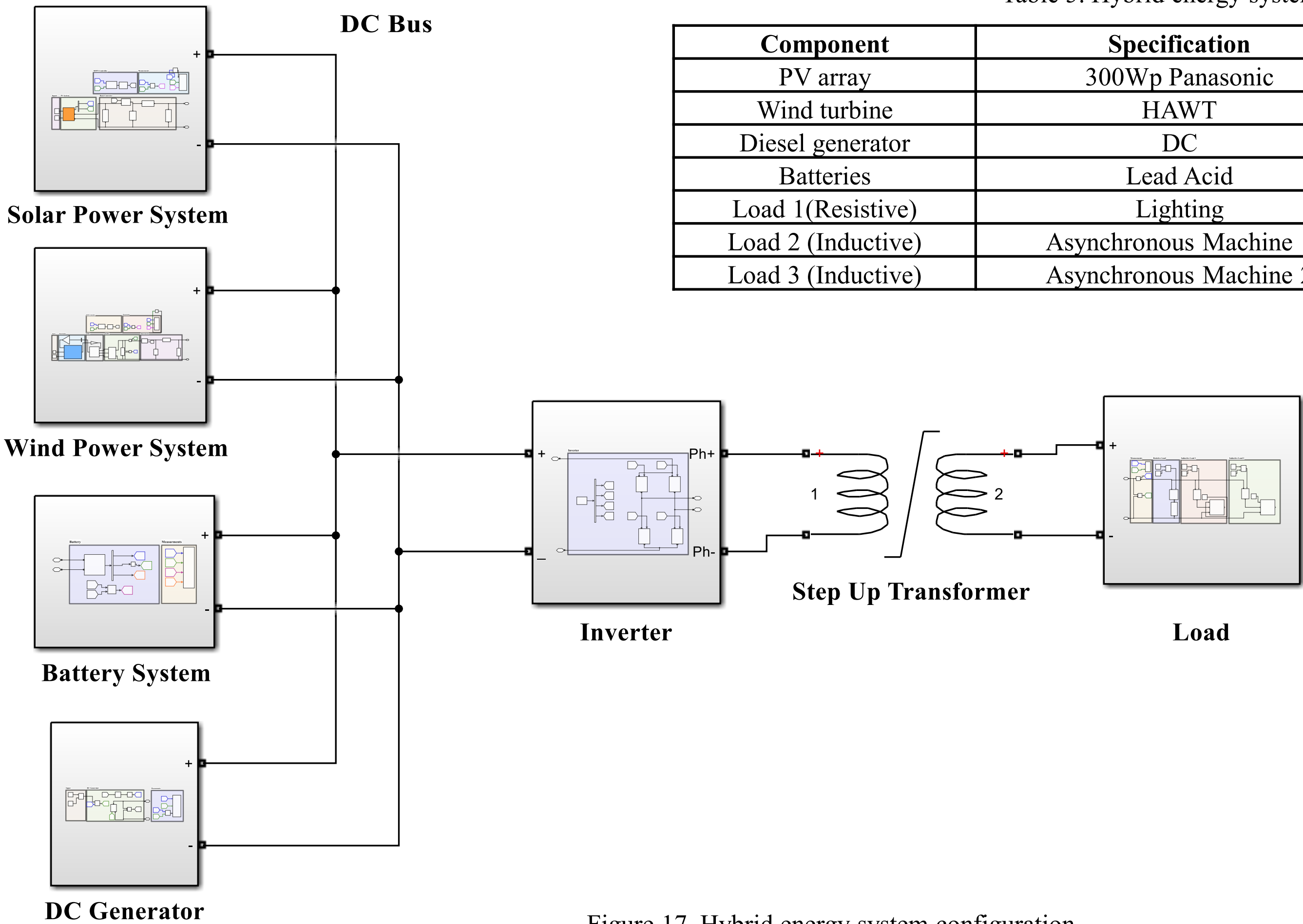

Figure 17. Hybrid energy system configuration.

Dynamic modeling of Solar Power System

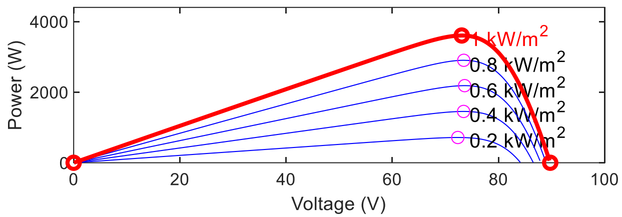

Figure 18. The array P-V curve.

For 2 series and 6 strings in parallel

Table 6. Each PV module specifications.

Parameter	Value
Maximum Power (W)	300.3588
Open circuit voltage V_{OC} (V)	44.87
Short-circuit current I_{SC}(A)	8.73
Voltage at maximum power point V_{mp}(V)	36.54
Current at maximum power point I_{mp} (A)	8.22
Temperature coefficient of V_{OC} (%/°C)	-0.312

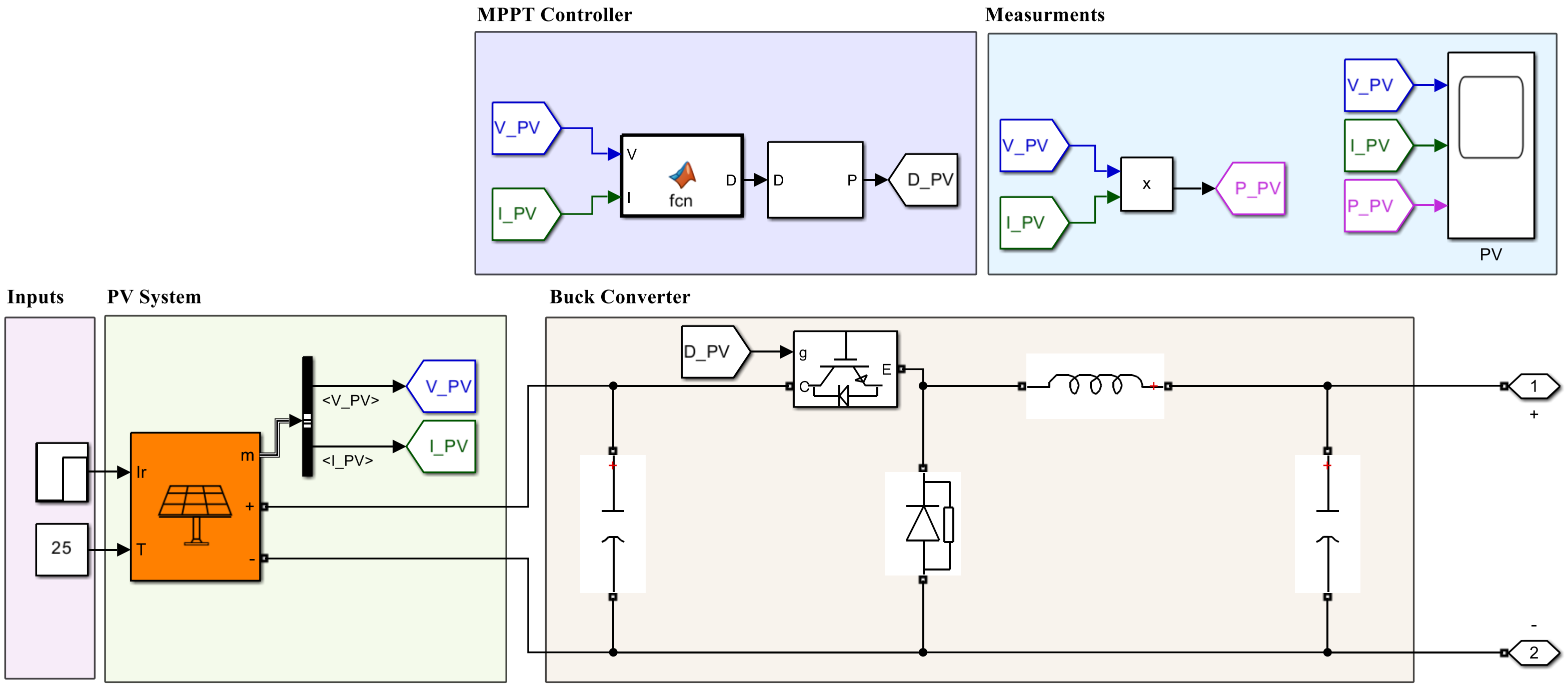

Figure 19. Solar power system configuration.

Dynamic modeling Wind Power System

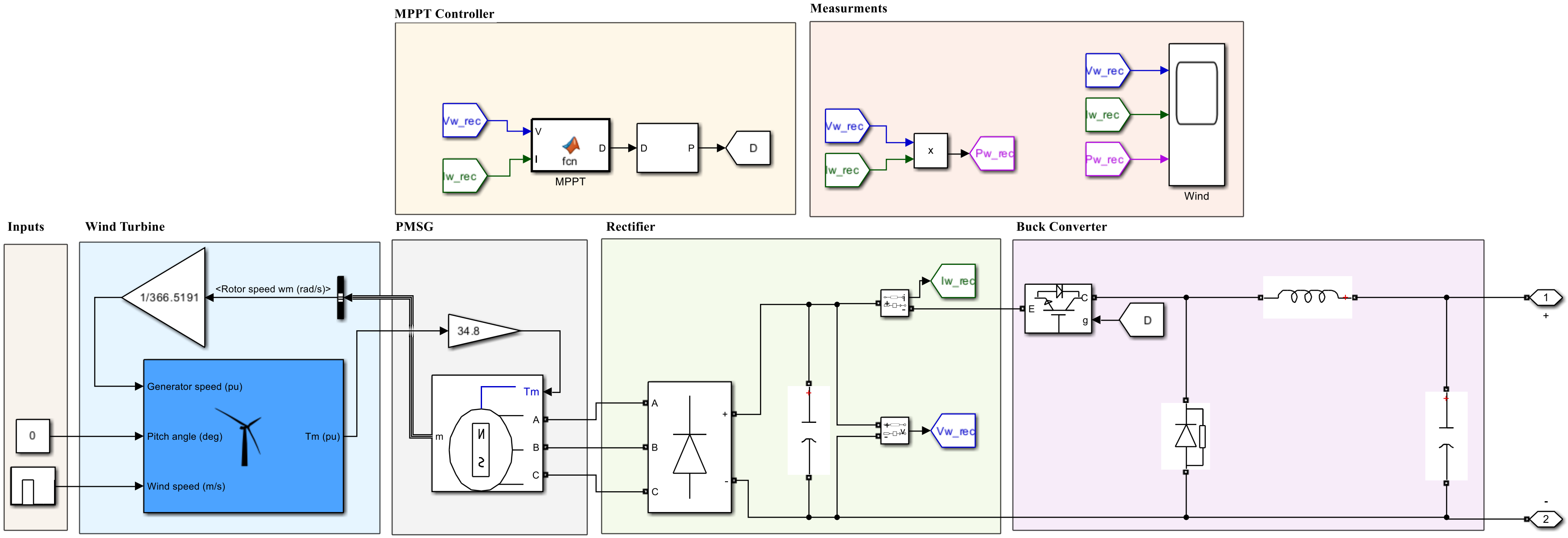

Figure 20. Wind power system configuration.

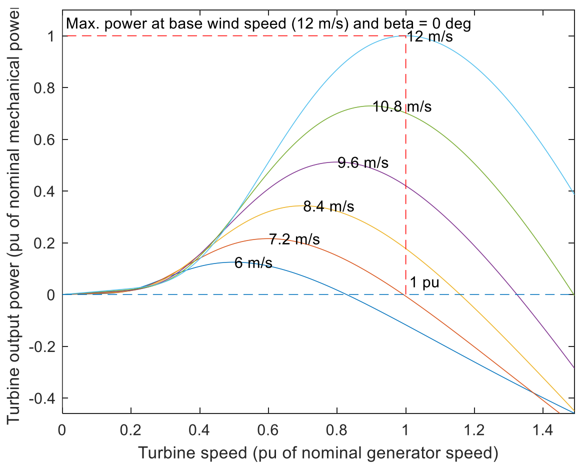

Figure 21. Turbine power characteristics with zero pitch angle.

Table 7. PMSG Specification.

Parameter	Value
Rated power (kW)	2
Rated Speed (RPM)	1800
Rated voltage (V)	48 VDC
Rated current (A)	0.10
Torque Constant Kt (Nm/Arms)	0.09
No. of Phases	Three Phase
Rotor Inertia (Kg/m^2)	0.002029
Power factor	≈1
Efficiency	Designed for 93%
Winding method	Star/Y
Insulation resistance	> 500 MΩ at 500Vdc

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Dynamic modeling DC Diesel Generator

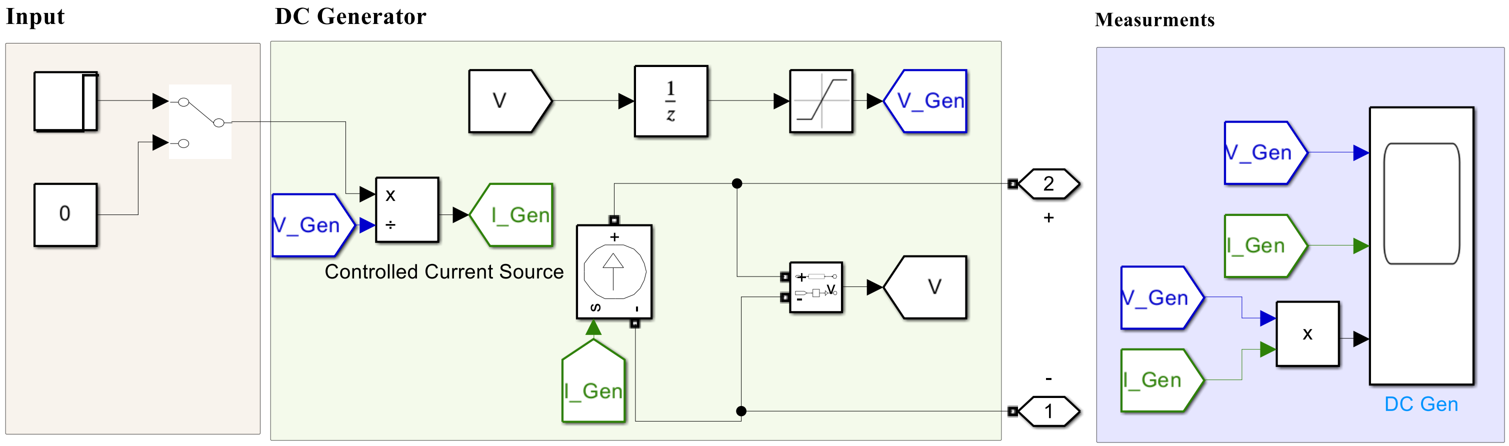


Figure 22. Modeling of DC diesel generator system configuration.

Dynamic modeling Battery System

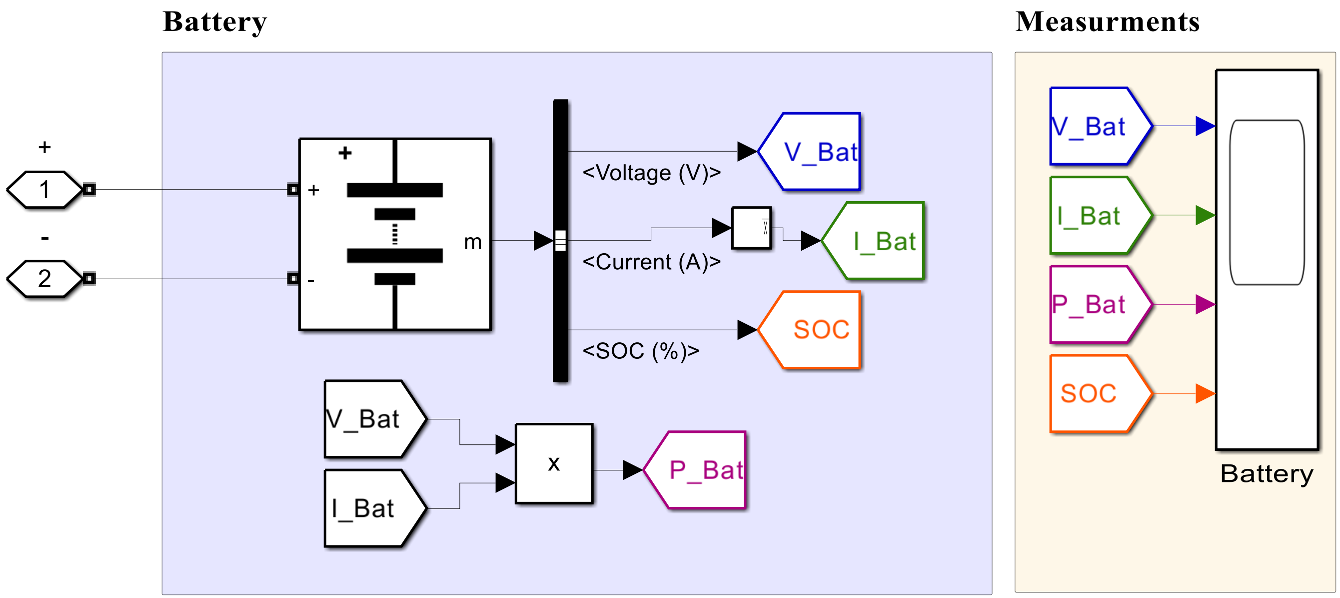


Figure 23. Model of the battery system.

Lead-acid battery
4 strings of 4 series-connected 12V batteries
(170 Ah each)

Dynamic modeling of Inverter

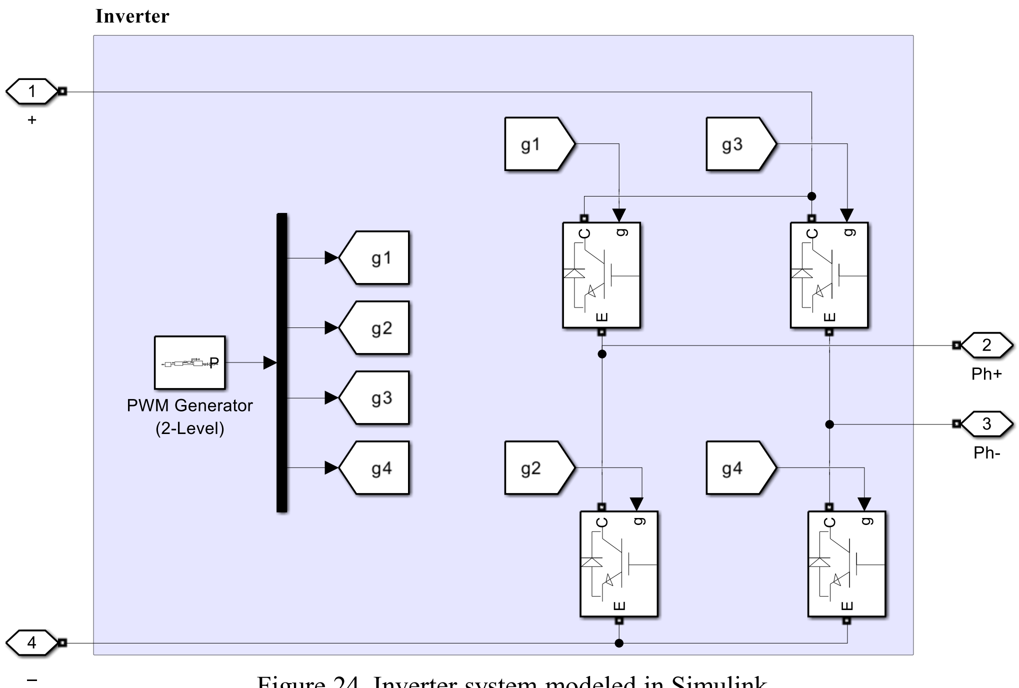


Figure 24. Inverter system modeled in Simulink.

A full-bridge inverter with a two-level PWM generator

Dynamic modeling of Step Up Transformer

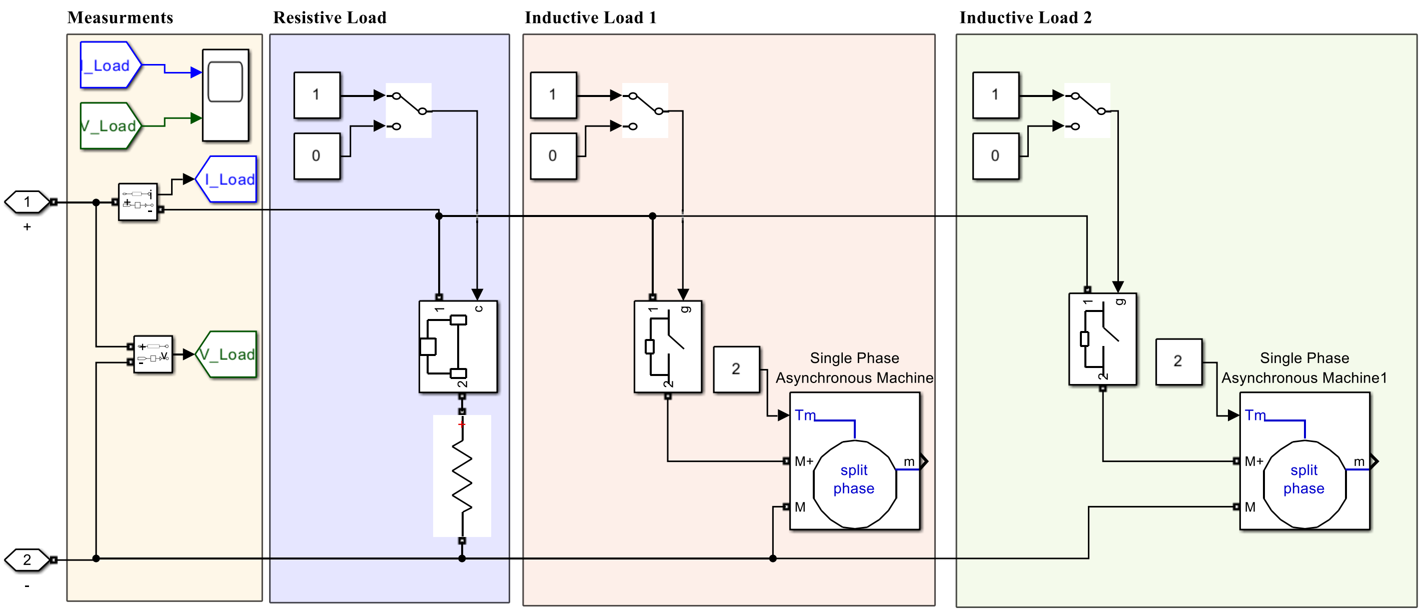
Table 8. Transformer Parameters.

Parameter	Description	Value
Nominal power	P_n(VA)	10000
Nominal frequency	f_n (Hz)	60
Parameters of Primary winding	$V_1(V_{rms})$ R_1(pu) L_1(pu)	[48/sqrt (2) 0.002 0.08]
Parameters of Secondary winding	$V_2(V_{rms})$ R_2(pu) L_2(pu)	[120 0.002 0.08]
Saturation characteristic	i1 phi1; i2 phi2; ...] (pu)	[0,0; 0.0024,1.2; 1.0,1.52]
Core loss resistance	[Rm] (pu)	[500]

A transformer with a capacity of 10 kVA is considered

Dynamic Simulation of Load

0.5 hp for the submersible pump



0.3 kW resistive load
(lighting system)

0.75 hp for the RO system

Figure 24. Load configuration in Simulink.

Result & Analysis

Table 9. Details of each Scenario.

Scenario	Time	Irradiance (W/m2)	Wind speed (m/s)	Generator relay
1	0	1000	12	off
2	1	200	6	off
3	2	200	10	off
4	3	800	6	off
5	4	800	6	on
6	5	200	10	on

Scenario 1: At time 1, with irradiance at 1000 W/m^2 and wind speed of 12 m/s, the system runs solely on renewable energy, and the diesel generator remains off.

Scenario 2: At time 2, irradiance drops to 200 W/m^2, and wind speed decreases to 6 m/s, but the generator is still off, testing the ability of the renewable sources and battery system to meet demand.

Scenario 3: At time 3, irradiance remains at 200 W/m^2, but wind speed increases to 10 m/s, and the generator stays off, assessing how increased wind compensates for lower solar output.

Scenario 4: At time 4, irradiance improves to 800 W/m^2, but wind speed stays at 6 m/s. The generator remains off, focusing on solar contribution.

Scenario 5: At time 5, with irradiance at 800 W/m^2 and wind speed still at 6 m/s, the generator is turned on, testing how the system behaves when backup power is introduced.

Scenario 6: At time 6, irradiance drops again to 200 W/m^2, and wind speed is at 10 m/s. The generator is on, ensuring backup power compensates for the reduced solar output.

Result & Analysis

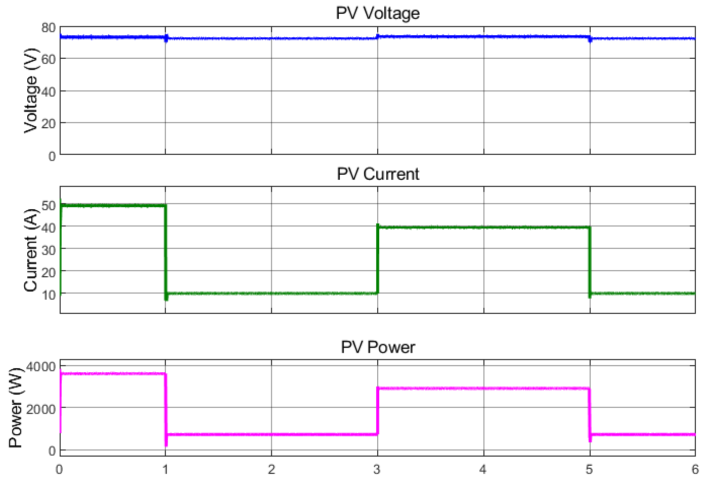


Figure 25. Dynamic response of PV system: a) Voltage; b) Current; c) Power.

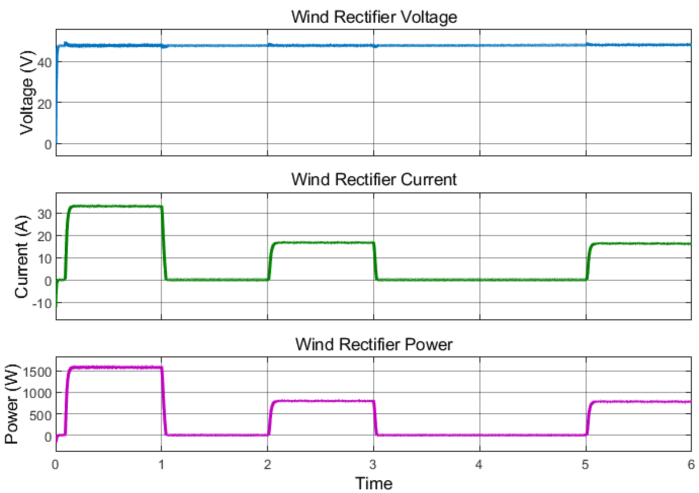


Figure 26. Dynamic response of wind rectifier: a) Voltage; b) Current; c) Power.

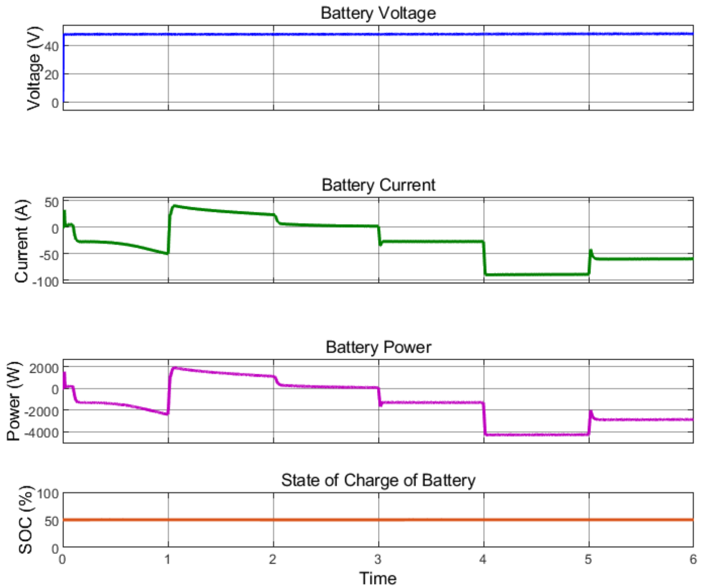


Figure 27. Battery system performance: a) Voltage; b) Current; c) Power; d) SOC.

Result & Analysis

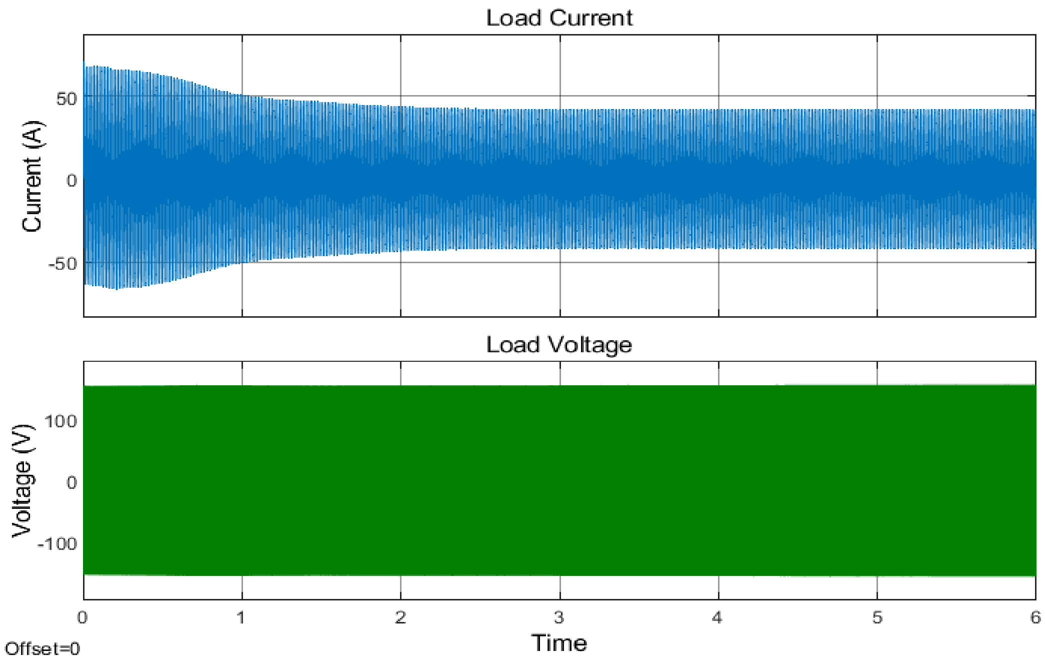


Figure 28. Load response under continuous operation (60 Hz, 120 V RMS): a) Voltage; b) Current.

Load response under continuous operation (60 Hz, 120 V RMS)

SCADA System Architecture

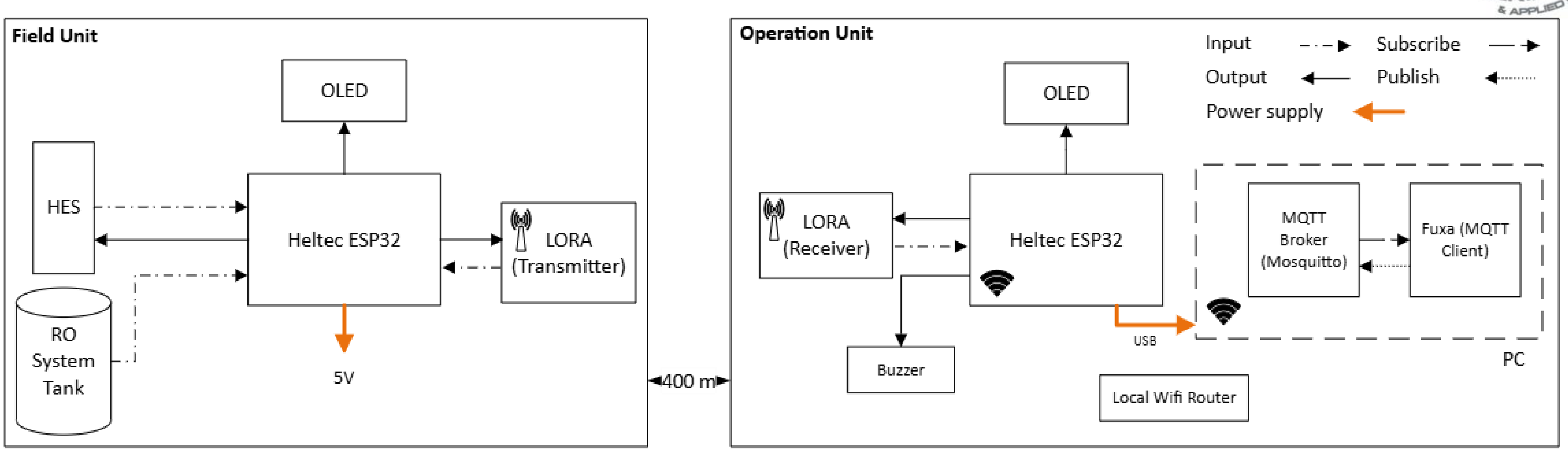


Figure 29. Proposed SCADA System Block Diagram in Field Unit and Operation Unit.

Functionality:

- Real-time monitoring ✅
- Diesel relay control ✅
- LoRa-based data transfer ✅
- No internet requirement ✅

Figure 30. SCADA system with 400 m LoRa communication path in McCallum, NL, Canada

Field unit: HES & RO system Simulator

Table 10. HES System Details.

Component	Specification
PV Module	85 W, Vmp: 17.9 V, Imp: 4.84 A
Wind Turbine Generator	400W,7 A, driven by a 90 V PMDC motor at 1800 rpm
Battery Bank	12 V, 110 Ah, sealed AGM lead-acid
Power Inverter	1 kW, 12 V DC to 120 V AC, 60 Hz
Solar Charge Controller	PWM, 12 V, 30 A max charging current,
DC Diesel Generator	DC Power Supply, 0–30 V, current-limited at ~5 A

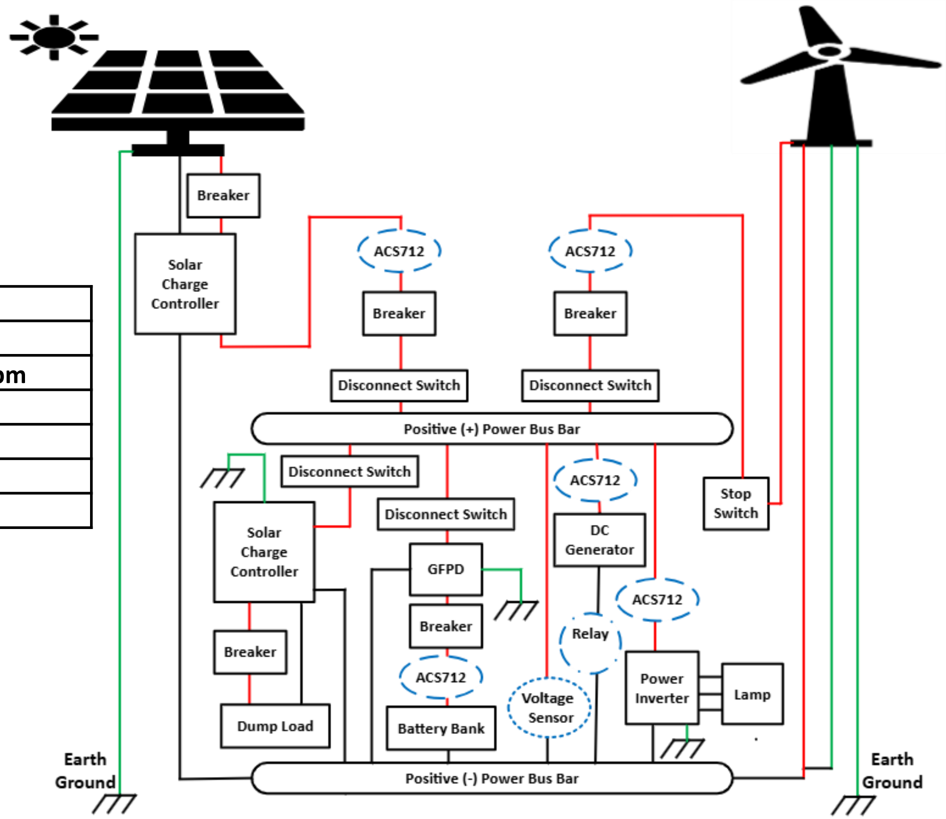


Figure 31. HES Architecture with Sensing and Relay Control.

Field unit: Actuation Subsystem

Table 11. Wifi LoRa 32 V3.2 Specification.

Component	Description
MCU	ESP32-S3FN8, dual-core, 240 MHz, with integrated Wi-Fi, Bluetooth, and LoRa (SX1262)
Input Voltage	- Via Type-C USB: 4.7–6V (typical 5V) - Via Battery: 3.3–4.2V - Via 5V Pin: 4.7–6V
Display	0.96-inch OLED, 128×64, I2C-connected
Power Outputs	3.3V (up to 500 mA), 5V (when USB powered), Vext (350 mA max)
ADC Inputs	ADC channels
LoRa TX Power	Up to 21 dBm
LoRa Sensitivity	Down to -137 dBm
LoRa Frequency	863–928 MHz
Power Consumption	- Active WiFi: ~115–150 mA - Sleep mode: 2 mA (USB) or 15 µA (VBAT)

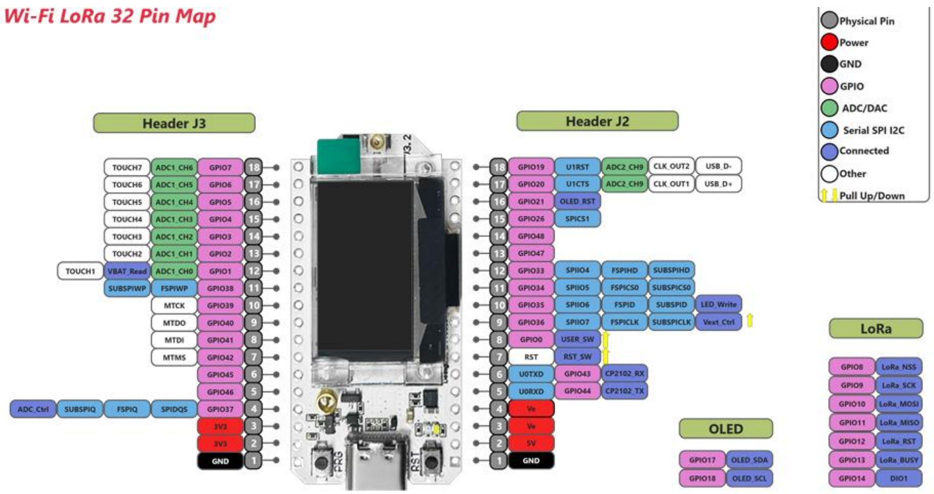


Figure 32. Wifi LoRa 32 V3.2 Pin Map

Field Unit: Sensors

- **Current Measurement**

Table 12. ACS712 Current Sensor Specification.

Parameter	Description
Sensor Type	ACS712 Hall-effect Current Sensor
Current Range	±5 A
Sensor Output	Ratiometric analog voltage
Typical Sensitivity	185 mV/A
Measured Components	- PV line - Wind turbine line - Battery charge/discharge line - Diesel generator line

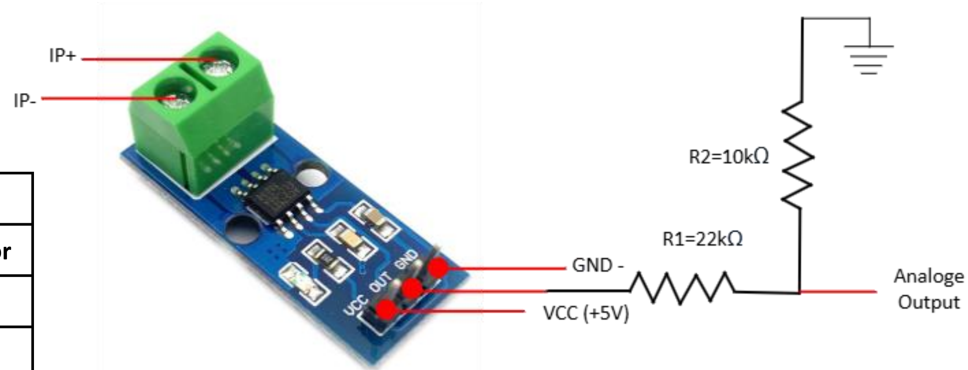


Figure 33. ACS712 Current Sensor Module.

- **Voltage Measurement**

Table 13. Voltage Divider Sensor Specification.

Parameter	Description
Sensor Type	B25 Voltage Sensor
Internal Configuration	Built-in resistive voltage divider
Input Voltage Range	Up to 25 V DC
Output Voltage Range	0–5 V analog output

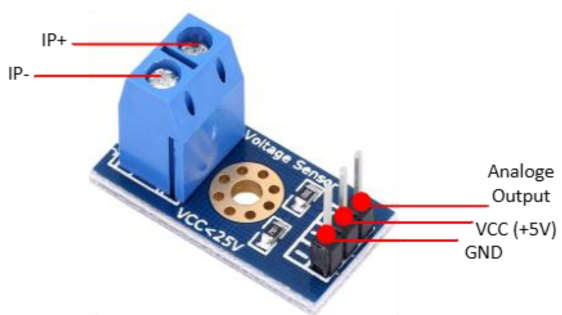


Figure 34. Voltage Divider Sensor Module.

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Field Unit: Sensors & Relay

- **Water Level Sensing**

Table 14. HC-SR04 Ultrasonic Distance Sensor Specification.

Parameter	Description
Sensor Type	Ultrasonic Sensor
Mounting Location	Above the RO (Reverse Osmosis) water tank
Operating Principle	Emits 40 kHz pulse and measures echo delay to determine distance
Measurement Range	2–400 cm
Accuracy	±3 mm
Beam Angle	15°
Output Type	TTL-compatible echo pulse

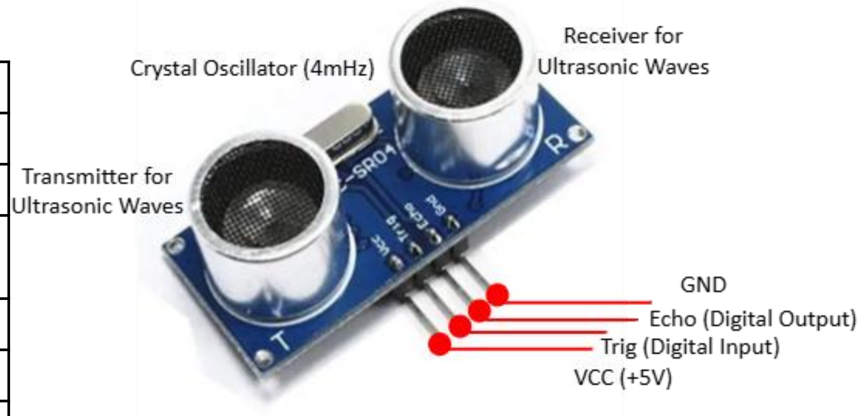

Figure 35. HC-SR04 Ultrasonic Distance Sensor Module.

- **Relay-Based Actuation**

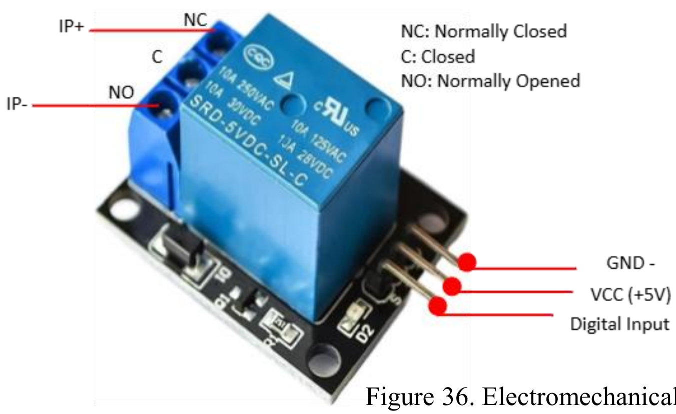

Figure 36. Electromechanical Relay Module.

Table 15. Electromechanical Relay Specification.

Parameter	Description
Actuator Type	Electromagnetic Relay (SRD-05VDC-SL-C)
Control Interface	Triggered via GPIO pin on ESP32
Switching Capacity	Up to 10 A at 250 VAC or 28 VDC
Contact Type	SPDT (Single Pole Double Throw)
Protection Features	Opto-isolation and flyback diode protection
Function	Used for actuation (e.g., controlling diesel generator)

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Operation Unit: Alarm

- **Alarming**

Table 16. Active Buzzer Module Specification.

Parameter	**Specification / Description**
Component Type	**Miniature Electronic Buzzer**
Part Number	**35-0905**
Rated Voltage	**5 V DC**
Sound Output	**≥85 dB @ 10 cm**
Resonant Frequency	**3.1 kHz ± 0.5 kHz**
Response Time	**≤50 ms**
Mounting	**Through-hole with solder pins (2 pins, 7.6 mm pitch)**

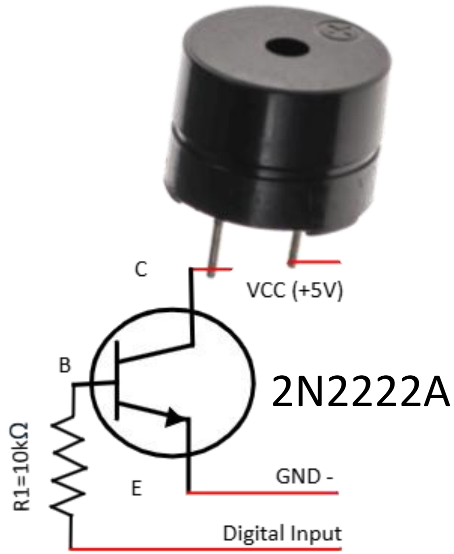

Figure 37. Active Buzzer Module.

Flowcharts Heltec ESP32 in Field Unit

Sender

Initialization:

1.Include necessary libraries;

2.Initialize GPIO pins for sensor inputs and relay output;

3.Initialize OLED display;

4.Initialize LoRa module with defined frequency for North America (915 Hz)

Sensor Measurement and Display:
5. Read values from analog sensors;

6. Measure water level;
7. Display all sensor values on OLED screen for local monitoring;

Data Transmission and Control Handling:
8. Format sensor values into a JSON string;
9. Transmit JSON data via LoRa to Receiver Node;
10. Continuously check for incoming LoRa packet;

while LoRa receives control command packet do
  11. Parse JSON and extract relay control signal "ON" or "OFF";
  12. Set relay GPIO pin accordingly to control diesel generator;
end
13. Delay and return to Step 5;

Figure 38. Algorithm implemented in the IDE for the ESP32 module in the Field Unit.

IDE

Flowcharts Heltec ESP32 in Operation Unit

Receiver

Initialization:

1.Include required libraries;

2.Connect to Wi-Fi using SSID and Password;

3.Connect to MQTT Broker using static IP address ;

4.Initialize OLED display and LoRa module;

Main Loop – Data Reception and Forwarding:

5. Listen for LoRa packets from Sender Node;
6. Upon data reception, parse JSON sensor data;
7. Display parsed values on OLED screen;
8. Publish each value to MQTT topics for visualization in FUXA;

Water Level Safety Condition:

9. **if** water level < 50% **then**
10. Activate buzzer GPIO

    else

        11. Turn off buzzer;

    end

Command Handling from FUXA via MQTT:

12. Subscribe to MQTT DC Diesel Generator control topic;
13. **if** a new MQTT message is received **then**

        14. Parse "ON" or "OFF" command;

        15. Send command via LoRa to Sender Node;

    end

16. Go to step 5;

Figure 39. Algorithm implemented in the IDE for the ESP32 module in the Operation Unit.

IDE

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Flow of Data

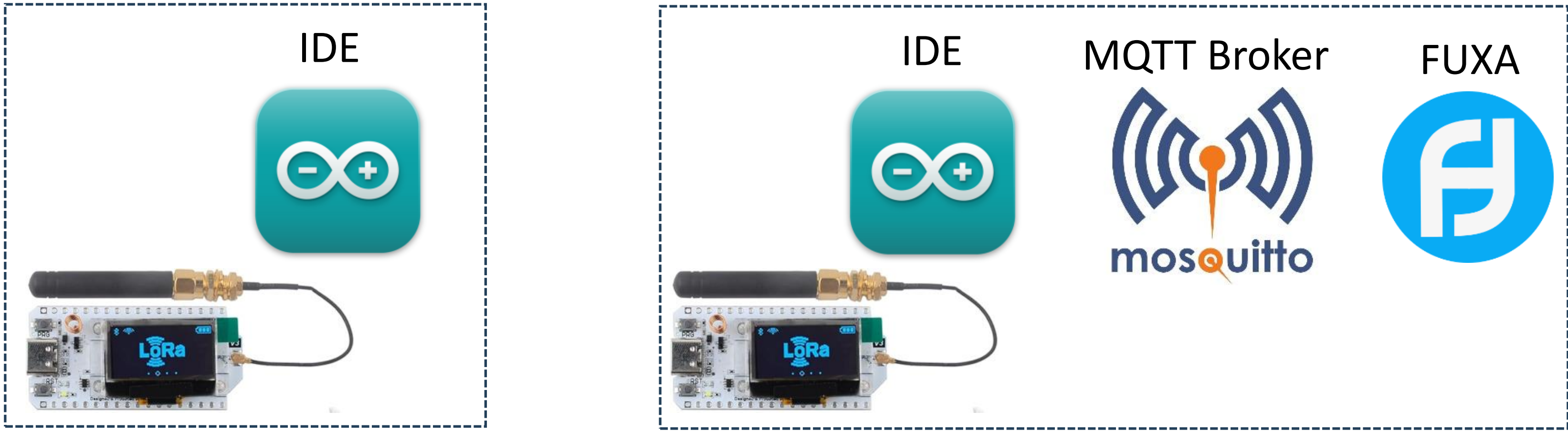


Figure 40. Data Flow between Field & Operation Unit.

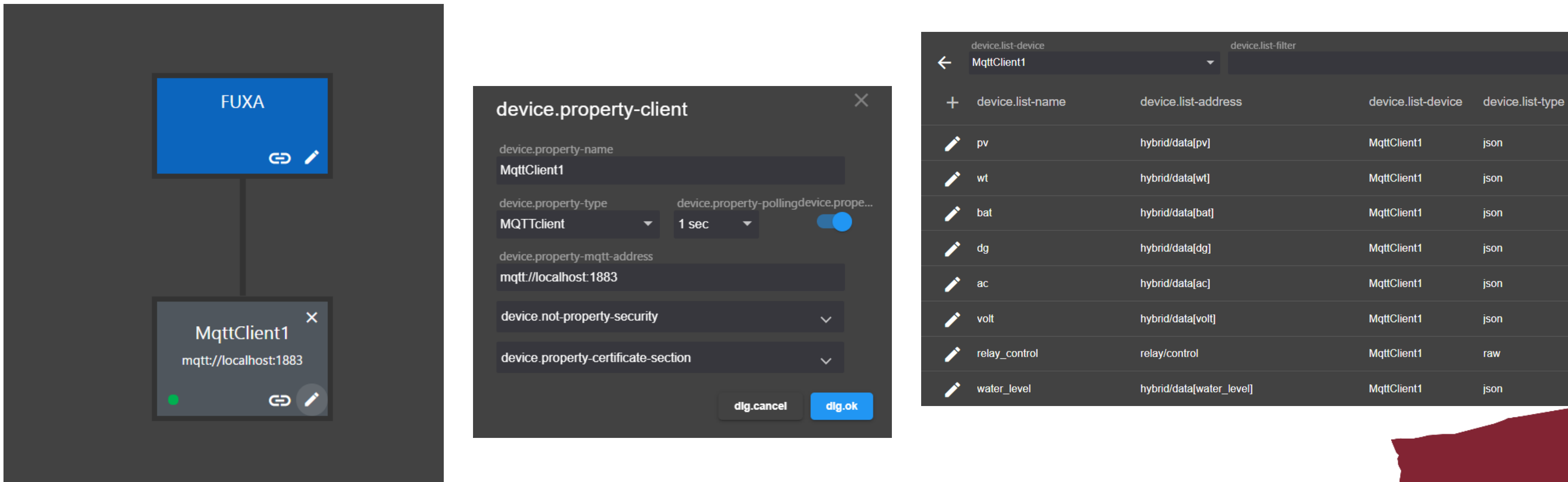


Figure 41. FUXA and MQTT connection and Tag creation in FUXA .

Experimental Test Set Up

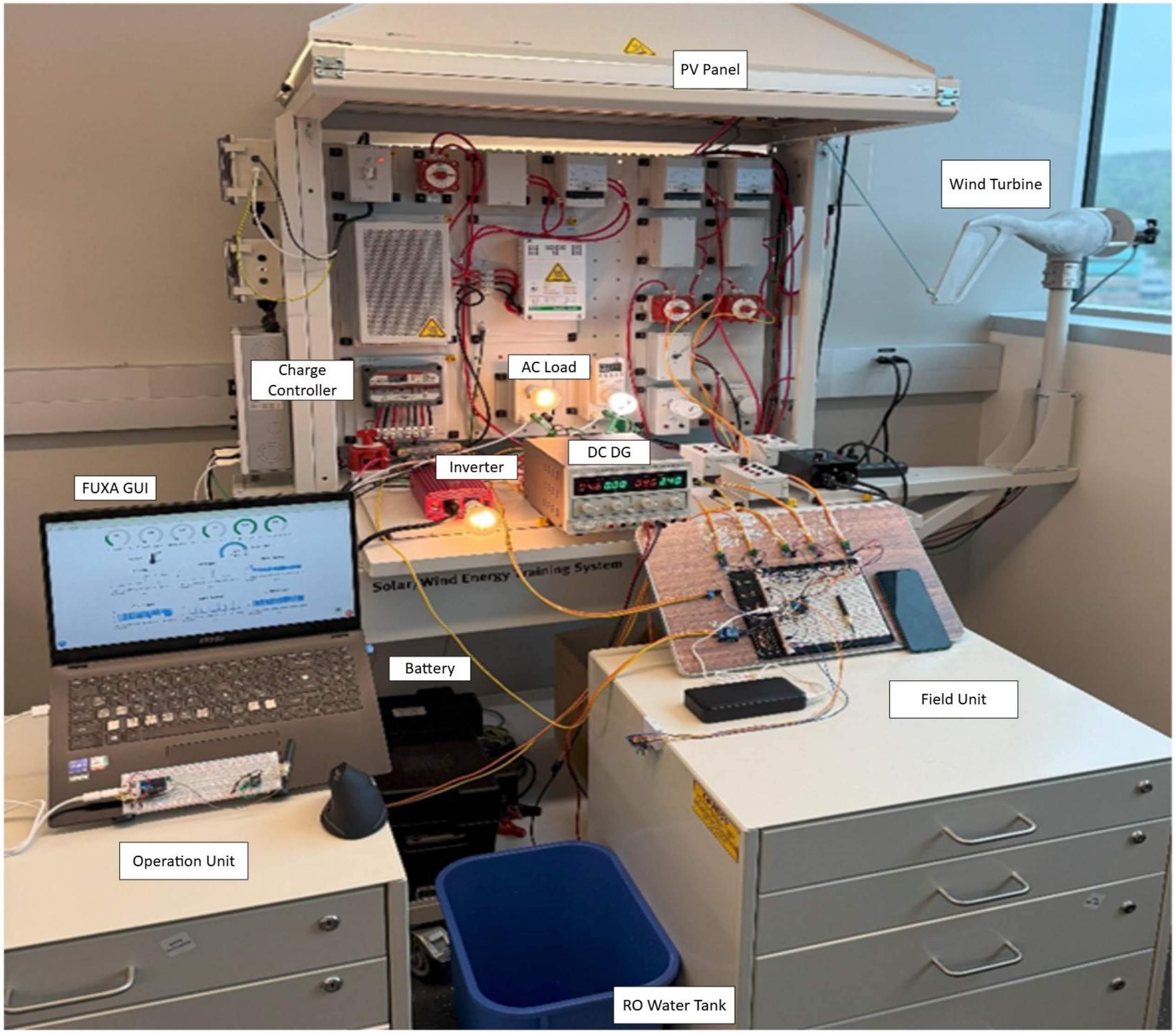


Figure 42. A Photo Of Experimental Test Set Up in the Lab

Result

Scenario	1
PV	On
WT	Off
DC DG	Off
Inverter	Off

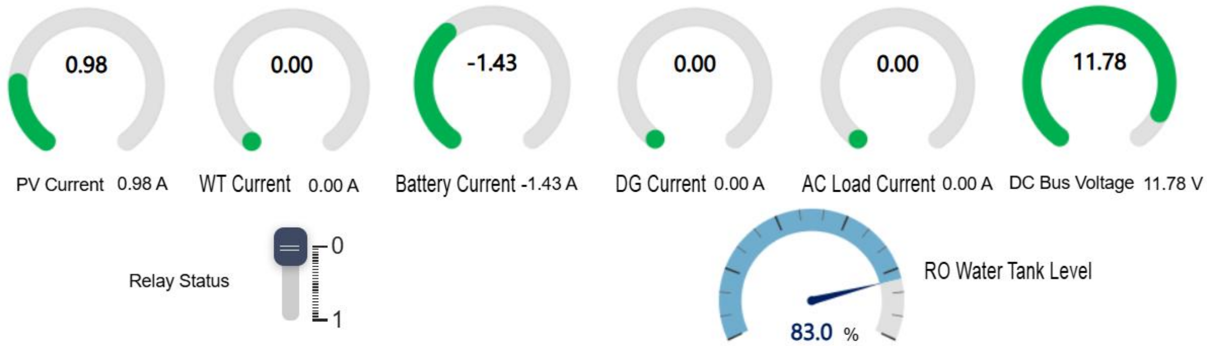
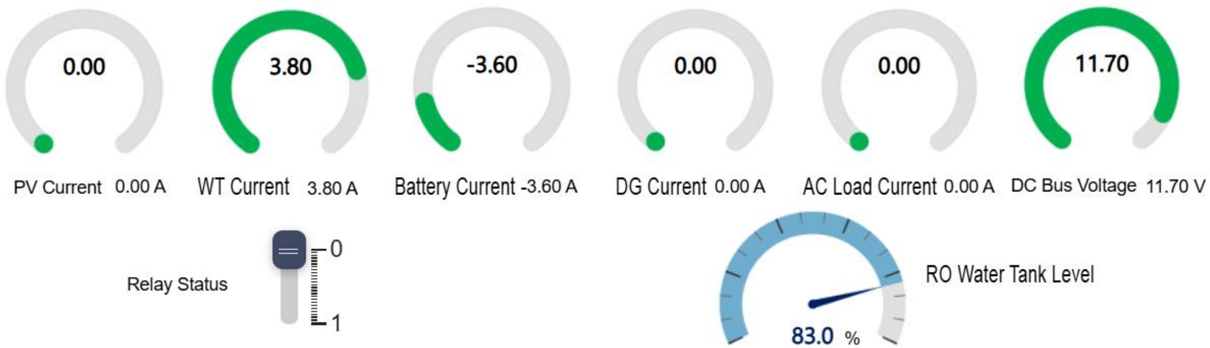


Figure 43. GUI of scenario 1.



Scenario	2
PV	Off
WT	On
DC DG	Off
Inverter	Off

Figure 44. GUI of scenario 2.

Result

Scenario	3
PV	On
WT	On
DC DG	Off
Inverter	On

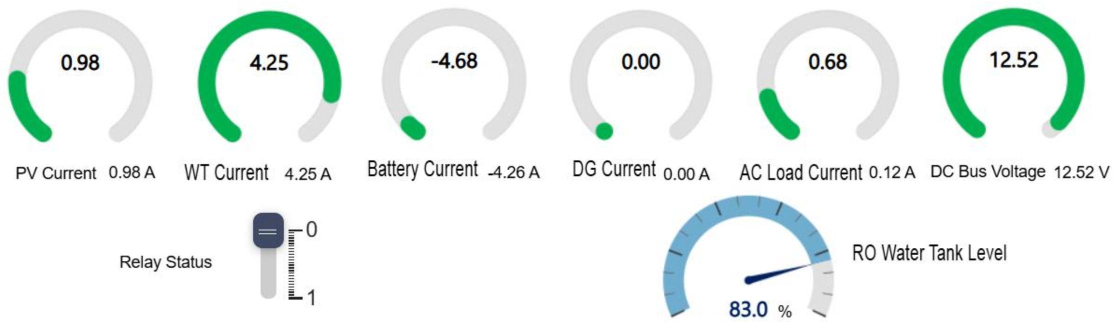


Figure 45. GUI of scenario 3.

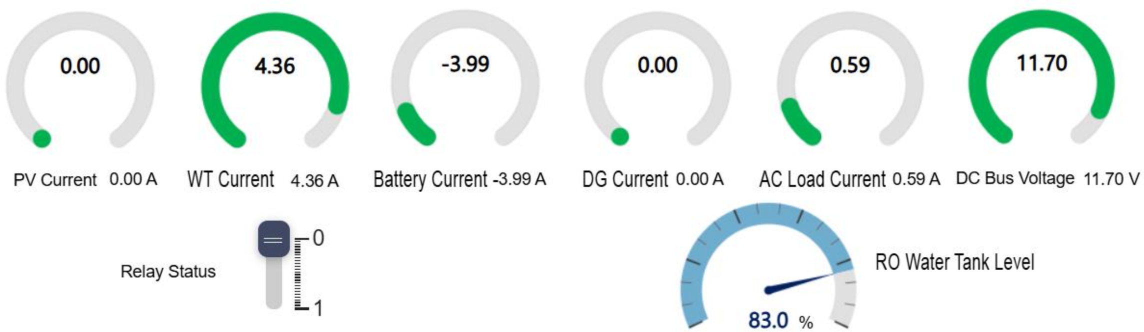


Figure 46. GUI of scenario 4.

Scenario	4
PV	Off
WT	On
DC DG	Off
Inverter	On

Result

Scenario	5
PV	On
WT	Off
DC DG	Off
Inverter	On

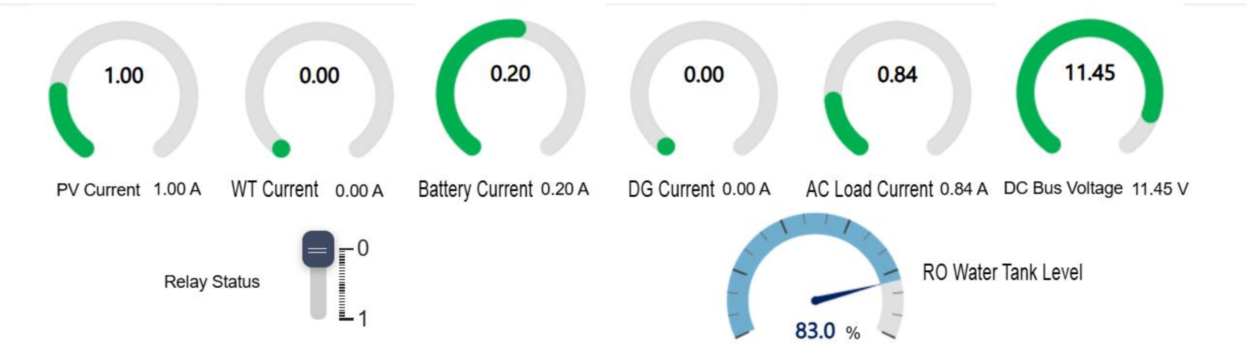


Figure 47. GUI of scenario 5.

Scenario	6
PV	Off
WT	Off
DC DG	Off
Inverter	On

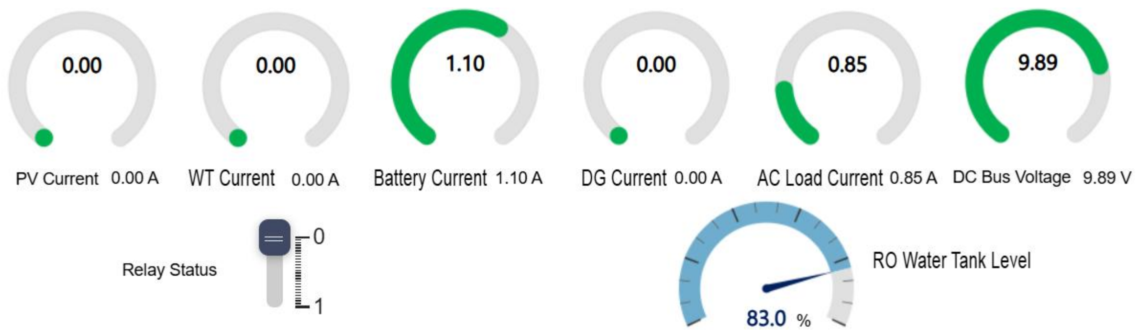


Figure 48. GUI of scenario 6.

Result

Scenario	7
PV	Off
WT	Off
DC DG	On
Inverter	On

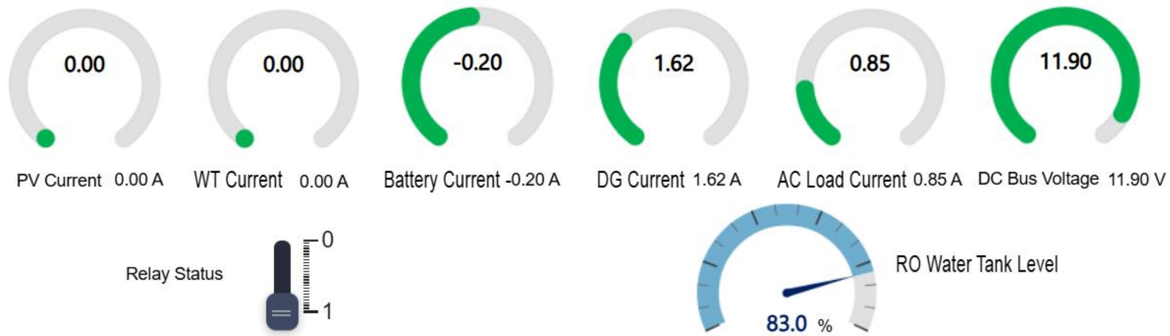


Figure 49. GUI of scenario 7.

Conclusion

•Developed an **integrated solution** for energy access and water quality in off-grid communities.

•Selected **McCallum, NL** as the case study due to diesel dependence, isolation, and water contamination.

•Sized an RO system based on **local water demand** and environmental analysis.

•Designed a **hybrid renewable energy system** (PV, wind, diesel, battery) using **HOMER Pro** to minimize cost and diesel use.

•Simulated system dynamics in **MATLAB/Simulink** to verify real-time **voltage and frequency stability** under variable conditions.

•Applied **MPPT control** to maximize renewable energy utilization.

•Developed a **fully offline SCADA system** using ESP32, LoRa, MQTT, and **FUXA**—with no Wi-Fi or internet required.

•Validated communication, monitoring, and **remote control** (e.g., diesel generator) through **lab testing**.

•Offered a **modular, cost-effective, and field-deployable** solution for remote clean water and power access.

•Supports **sustainable development goals** in Canada and other resource-limited settings.

Future Work

- Implement **AI-based energy management** for smart forecasting and dynamic dispatch among PV, wind, diesel, and battery.
- Integrate **machine learning** to reduce fuel use and improve system efficiency and responsiveness.
- Add **green hydrogen storage** via electrolysis as a long-duration backup; explore **CHP integration** for added value.
- Re-engineer into **modular, containerized systems** for rapid deployment in remote or emergency contexts.
- Improve simulations with **weather forecasting** and **adaptive control** for resilience under extreme conditions.
- Evaluate **RO efficiency improvements** (e.g., pressure recovery) and **alternative desalination** (e.g., forward osmosis, solar distillation).
- Upgrade SCADA with **satellite connectivity** (e.g., Starlink) for remote diagnostics and cloud sync.
- Expand **IoT sensor integration** for predictive maintenance and real-time system health monitoring.
- Enhance **scalability and robustness** for broader use in underserved and isolated regions.

List of Published Papers

- **F. Kafrashi**, T. Iqbal, "Sizing Optimization and Economic Modeling of a Stand-alone Hybrid Power System for Supplying RO System in McCallum," Journal of Electrical and Electronic Engineering (JEEE), Vol. 12, No. 1, pp. 1–8, January 2024.
- **F. Kafrashi**, T. Iqbal, "Dynamic Simulation of a Hybrid Energy System for Powering a Water Treatment Facility in McCallum, Newfoundland and Labrador," European Journal of Electrical Engineering (EJENERGY), Vol. 26, No. 1, pp. 48–56, 2024.
- **F. Kafrashi**, H. Golchin, T. Iqbal, "Monitoring and Control of a Remote Hybrid-Powered Reverse Osmosis Unit for McCallum, NL," submitted in Journal of Electrical and Electronic Engineering (JEEE)

Regional Conference Publications

- **F. Kafrashi**, M. Kashif, M.T. Iqbal, "Design and Simulation of a Floating Solar Reverse Osmosis Drinking Water System in Kish Island" the 33rd IEEE Newfoundland Electrical and Computer Engineering Conference (NECEC), November 14, 2024.

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Thank You!

Any questions?