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RENEWABLE MICROGRIDS FOR RESILIENCE ENHANCEMENT OF DIFFERENT LOADS WITH DIVERSE USAGE PATTERNS UNDER NATURAL DISASTER

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PROJECT DESCRIPTION AND OBJECTIVES

This study explores, develops, and assesses viable microgrid solutions for isolated islands, using Indonesia as an example. Initially, we assessed the probability of a photovoltaic (PV) and battery system surviving random outages of varying lengths. Subsequently, we utilized Homer Grid software to simulate multiple configurations, including PV, wind, battery storage, and generators and analyzed both economic and resilience outcomes. Our findings indicate that the resilience of a hospital, due to its daytime peaking load which aligns well with PV generation, is 35% higher than that of a hotel. Diverse usage patterns-wise, PV+WT MG showed only a 5% improvement in resilience compared to PV+BES MG.

TABLE I: DIFFERENT SCENARIO FOR ISLAND MICROGRID

S. #	Key Scenario	Description
1	DG	An independent diesel generator might be the solution.
2	DG+BES	Might be improved economically by including a battery.
3	PV+BES	Battery capacity in conjunction with a relatively big PV capacity is required.
4	DG+BES+PV	Adding a diesel generator, reduced the number of batteries and solar panels.
5	WT+BES	A huge battery and relatively large capacity of wind turbines are required.
6	DG+BES+WT	A diesel generator generates the required electricity when there is no wind or battery charge.

TABLE II: MICROGRID COMPONENTS CAPACITY IN %

Component	Capacity in %
PV array	0, 25, 50, 75, 100
BES	0, 6, 12, 18, 24 h
Generator	0, 25, 50, 75, 100
Wind turbines	0, 25, 50, 75, 100

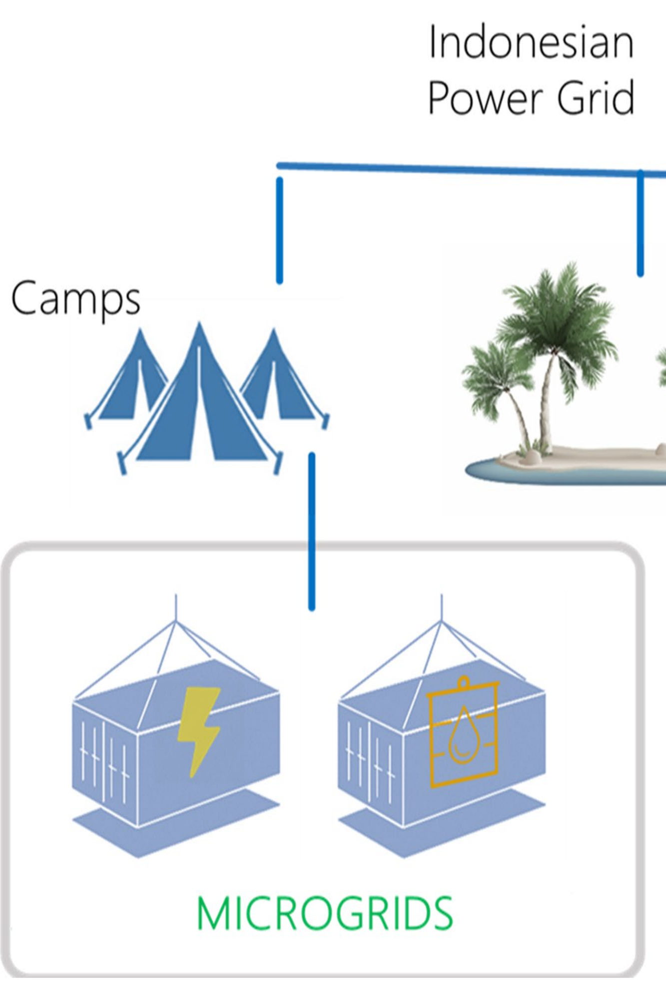

Fig. 1. System architecture

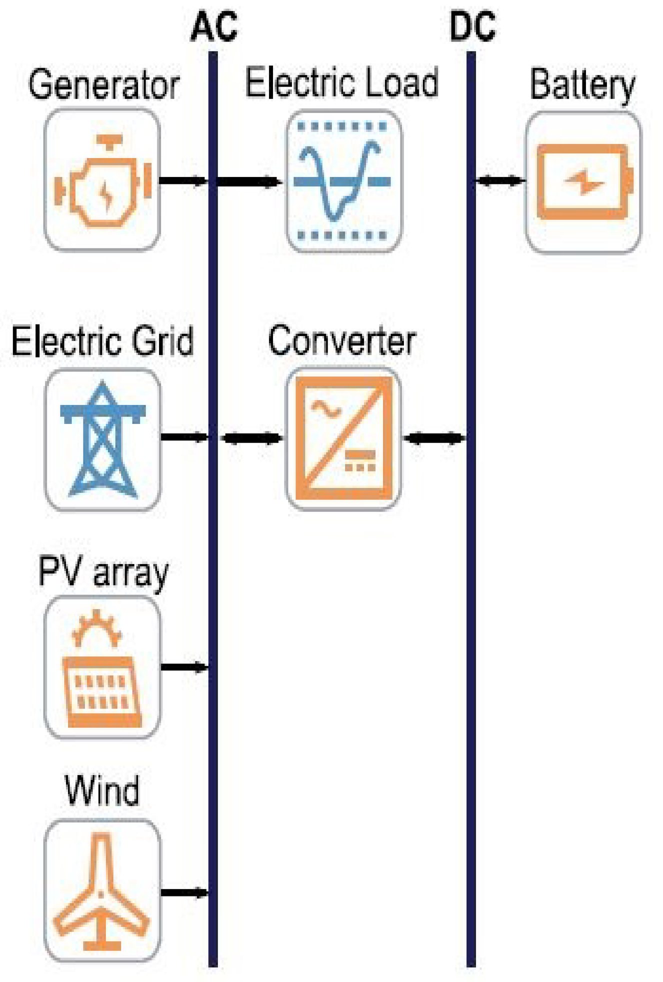

Fig.2. MG architecture

METHODOLOGY

- The Homer Grid offered the best technology, system size, and smallest net present cost (NPC) possible.
- The project life of 25 years is considered. The 10% increase in electricity cost and operation and maintenance cost per year is considered for simulations.
- An 8% discount rate and 2.8% inflation rate is used by Homer Pro for simulation.
- Value of Lost Load (VoLL) $100/kWh.
- For this calculation, we used a renewable-only MG consisting of a 75% PV array, a 12 h battery, and the critical load (50% of the total load) assuming the battery state of charge (SoC) is 100% and 3-day (72 h) outage.

The surviving probability of an Outage for a renewable only Microgrid:

$$SP = \sum_{t=1}^{N} sp(\,surviving\ an\ outage\ of\ \ t\ hours)\,.(\,1\ h)\quad(1)$$

where N is the length of the outage under consideration. For our case study N = 72 h,

$$SP = \sum_{t=1}^{72} sp(\,surviving\ an\ outage\ of\ \ t\ hours)\,.(\,1\ h)\quad(2)$$

TABLE III: SURVIVING PROBABILITY OF AN OUTAGE %

Location	Load	Prob = 90 % (h)	Prob = 50 % (h)	Prob = 10 % (h)
A	Hospital	22	127	2223
	Medical Clinic	21	85	285
	Hotel	16	45	135
B	Hospital	16	65	251
	Medical Clinic	16	61	189
	Hotel	14	35	99
C	Hospital	19	55	216
	Medical Clinic	18	57	235
	Hotel	16	39	79

RESULTS

The resilience analysis of renewable microgrids shows:

(1) Resilience varies with load patterns and local resources, e.g., a hospital in Location A can sustain a 127-hour outage with 75% PV and 12-hour BES, while a hotel in Location C can only manage 39 hours.

(2) Survival probability is 35% higher for hospitals than hotels for 72-hour outages, and 5% higher in Location B than C.

(3) Hotels have lower resilience, with less than a 25% chance of surviving a 72-hour outage, compared to over 45% for hospitals and offices.

(4) A 50% PV, 50% wind, and 6-hour BES system can sustain 3-day outages effectively.

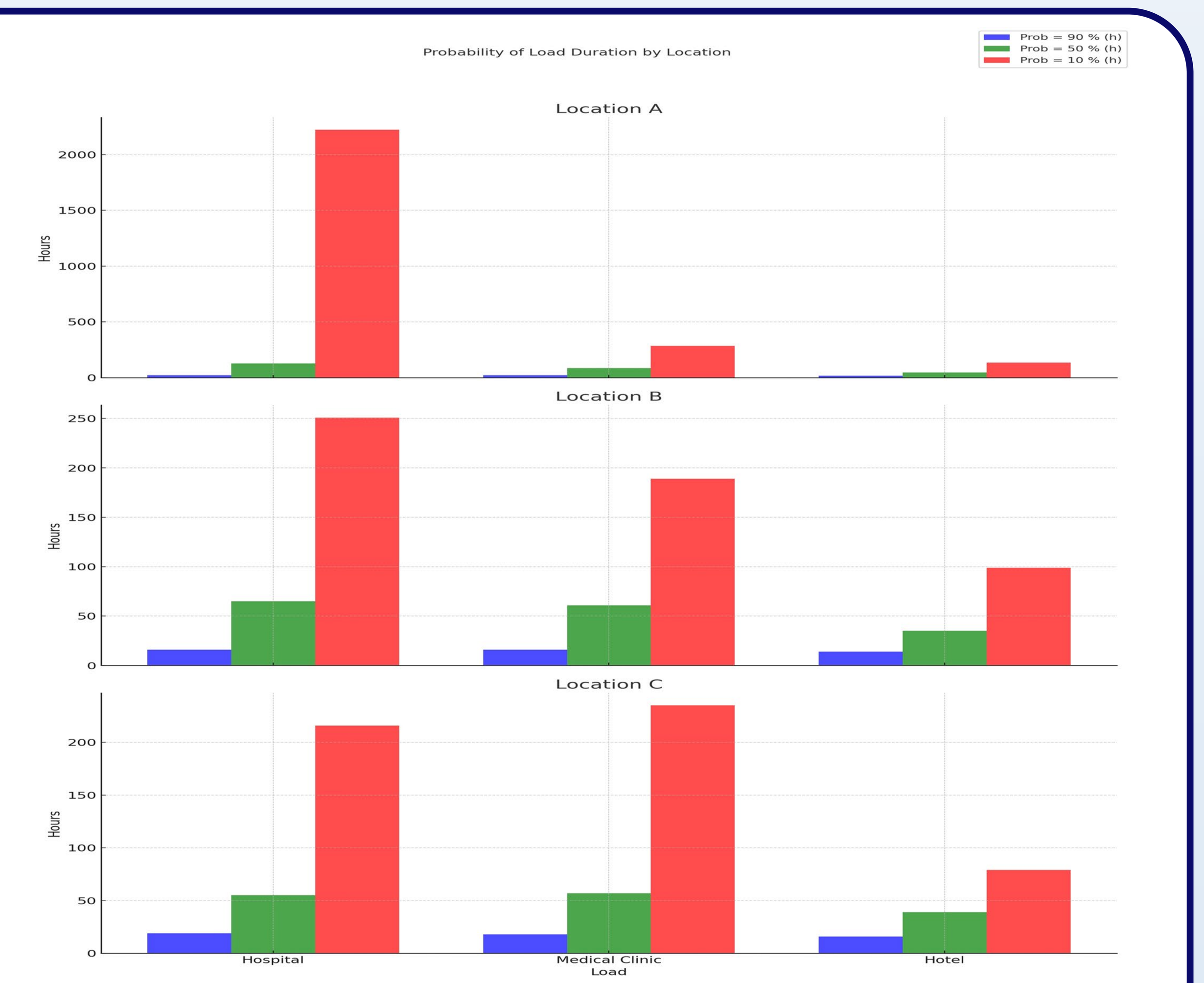

Fig.3. Surviving probability with different loads and locations with 75% PV & 12 h BES

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