AI-Powered Autonomous Microgrids for Climate-Resilient Smart Villages

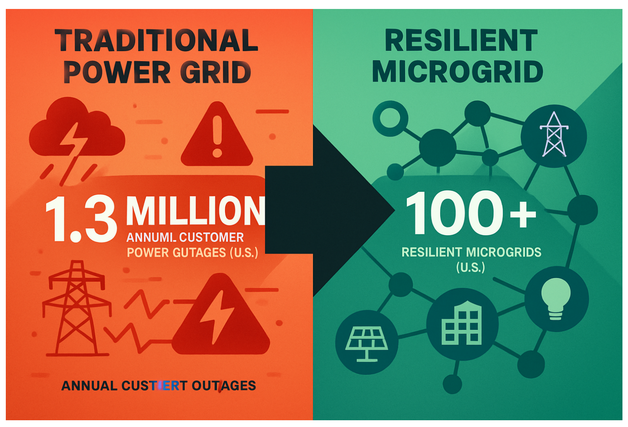
Rajasree Dutta, Pritam Bhakta, Prateek Kumar

Dept of Computer Science and Engineering, Amity School of Engineering and Technology Kolkata

The Problem

Energy Crisis in Rural Areas:

- 1+ billion people lack reliable electricity
- Climate events disrupt centralized grids 40% more frequently
- Energy inequality excludes communities from decision-making

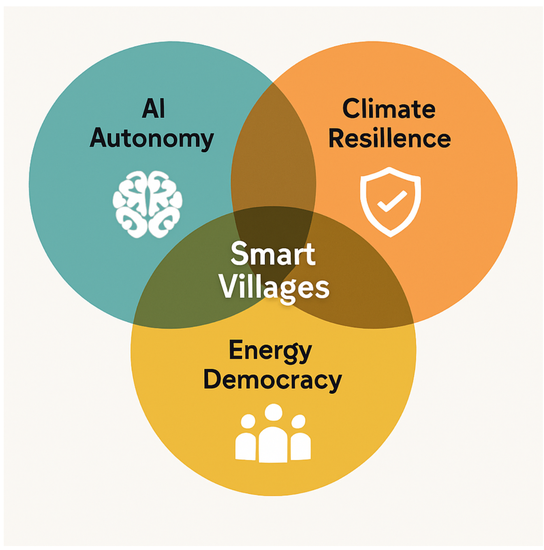


Traditional grid failure during climate events vs. Resilient microgrid network

Our Solution

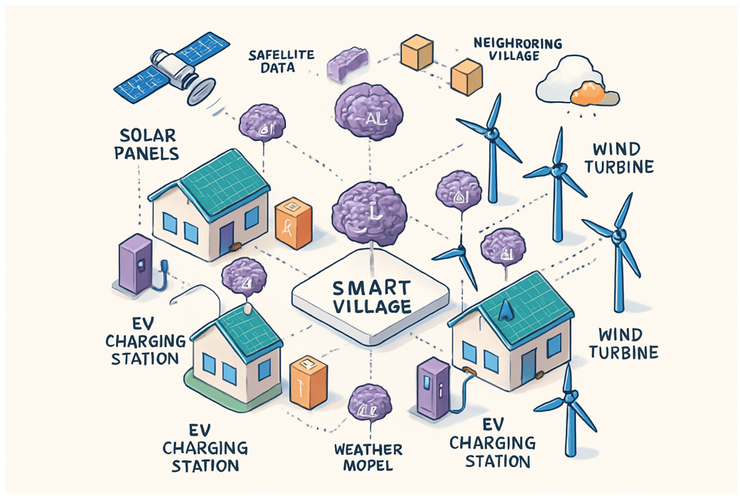
Fully Autonomous AI-Managed Energy Communities

- Multi-agent reinforcement learning for real-time optimization
- Physics-informed neural networks for climate forecasting
- Blockchain governance for community ownership



AI Autonomy, Climate Resilience, Energy Democracy

System Architecture



Village Layer: Houses with solar panels, wind turbines, battery storage, EV charging

AI Control Layer: Edge AI nodes, wireless communication, central hub

Blockchain Layer: Distributed ledger, smart contracts to neighbors

Weather Integration: Satellite data, forecast models feeding control

Key Algorithms & Process Flow

1. Multi-Agent Reward Function:

$$R = \alpha \cdot \text{Cost} + \beta \cdot \text{Reliability} + \gamma \cdot \text{Carbon} + \delta \cdot \text{Benefit}$$

- $\alpha, \beta, \gamma, \delta$: dynamic weighting factors
- Cost: operational & maintenance costs
- Reliability: system uptime stability
- Carbon: emission levels tracking
- Benefit: community social gains

2. Physics-Informed Weather Model:

$$\frac{\partial T}{\partial t} + u \cdot \nabla T = \alpha \nabla^2 T + S$$

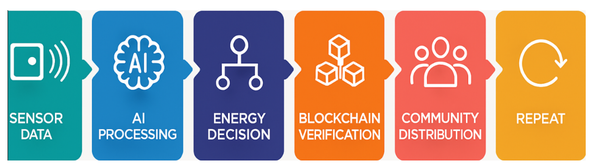
- T: temperature variable
- u: velocity field (wind/advection)
- α: thermal diffusivity
- S: solar radiation source term

3. Blockchain Consensus Score:

$$\text{Score} = w_1 \cdot \text{Avail} + w_2 \cdot \text{Price} + w_3 \cdot \text{Carbon}$$

- w_1, w_2, w_3: consensus weights
- Avail: energy availability
- Price: dynamic cost per unit
- Carbon: environmental impact

Process Flow:



Environmental Impact

Scalability Analysis:

- 3 pilot locations: India, Kenya, Peru
- Population served: 1B+ rural residents

UN SDG Alignment:

Novel Contributions:

Aspect	Traditional	Our Approach
Control	Centralized	Multi-Agent AI
Ownership	Utility	Community
Resilience	Reactive	Predictive
Trading	Fixed Rate	Dynamic P2P

Market Position: First integration of AI autonomy + blockchain democracy + climate resilience

TRL: 3–4

Market: $6.82B opportunity

Results & Performance

Performance Targets (Expected):

Metric	Target
Renewable Penetration	95%
System Uptime	99.9%
Cost Reduction	40%
Carbon Emissions	NET ZERO

Carbon Reduction Potential:

- Traditional Grid: 12 tons CO_2/year
- AI Microgrid: 0.5 tons CO_2/year
- **Savings per village: 11.5 tons CO_2/year**

Key Takeaways

- **TECHNICAL:** Autonomous AI + blockchain creates unprecedented rural energy control
- **SOCIAL:** Community ownership drives energy justice and local economic empowerment
- **ENVIRONMENTAL:** Climate-resilient design ensures reliable clean energy access

KEY REFERENCES

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MORE INFORMATION

Prateek Kumar, Pritam Bhakta, Rajasree Dutta

Dept of Computer Science and Engineering

Amity School of Engineering and Technology Kolkata

Website:prateekcandwill.github.io/autonomous-microgrid-ai/