A Case for TENGs in Agricultural Brutalism

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ABSTRACT

This study tests whether a tiny home can achieve seasonal electricity autonomy using site-specific triboelectric textiles augmented by human power. The system is conceived as an environmental sculpture with five generator methods: a wind chevron fence, a D-TENG rain canopy, a cascading runoff aqueduct, an interactive TENG totem, and an indoor exercise-bike generator. Larger spatial elements (proposed Superyurt or Tiny House with a passive root cellar) are treated qualitatively as carriers and excluded from generation tallies. Two Midwestern contexts are simulated; Omaha, Nebraska (high-drainage loess with elevated wind shear) and Iowa City, Iowa (clay-rich till with strong micro-precipitation events). Drivers include wind speed, precipitation depth, and temperature-dependent air density; behavioral inputs (pedaling frequency and power); and design variables (area allocation, orientation, conversion efficiency, and battery state-of-charge limits). The outcome is an empirical feasibility map of sculptural micro-generation, estimating when localized kinetic textiles plus routine human effort can meet residential loads in volatile climates without grid support using a case study method.

KEYWORDS (Gemini 3.5 Flash generated from notes)

Agricultural Brutalism, Architecture of Sufficiency, Triboelectric Nanogenerator (TENG), Droplet-based TENG (D-TENG), Comparative Micro-Climate Analysis, Carry-Capacity Constrained Autonomy, Kinetic Wind-Chevron Fence, Multi-Tiered Hydrologic Cascade, Participatory Interactive Energy Generation

PROPOSED METHOD

This comparative case study tests an architecture of sufficiency by simulating multi-modal triboelectric nanogenerator systems under the municipal guidelines and micro-climates of Omaha, Nebraska, and Iowa City, Iowa - integrating weather data (wind speed, precipitation depth, temperature) with literature-based engineering models to estimate conversion performance and battery storage efficiency for a passive sculptural installation. Because full construction, land acquisition, and real-world testing would span roughly five years, a computational study will be conducted accessing historical weather data, allowing a controlled evaluation of design variables. Dynamic weather inputs will be run against site constraints and user behavior to quantify operational envelopes. The outcome is a location-specific feasibility map that identifies the environmental and behavioral thresholds required to achieve off-grid electrical autonomy using the following variables:

Variable Category	Exogenous Meteorological Drivers
Metric/Parameters	Wind Speed (v, m/s), Rainfall (Rd, mm), Ambient Temp (T, °F)
Role in Simulation & Calculations	Sets boundary limits on raw environmental mechanical energy available.

Variable Category	Physical Modality Mix & Configuration
Metric/Parameters	Area A (sq ft), Chevron angle (θ), Orientation vector ($\vec{u}$)
Role in Simulation & Calculations	Governs geometric efficiency and spatial alignment to dynamic weather fronts.
Variable Category	Conversion & Storage Efficiencies
Metric/Parameters	Circuit rectification loss (η_conv), Battery round-trip (η_stor)
Role in Simulation & Calculations	Constrains real-world power generation versus theoretical mechanical power.
Variable Category	Participatory/Behavioral Inputs
Metric/Parameters	Bicycle exercise rate (P_bike, Watts) & duration (t, hrs/day)
Role in Simulation & Calculations	Provides user-driven, predictable indoor generation offset when weather inputs are low.
Variable Category	Core Calculated Subsystems
Metric/Parameters	Superroof (PV + D-TENG), Fence, Aqueduct, Totem, Bicycle Generator
Role in Simulation & Calculations	Represents the active variables inside the mathematical modeling loop.
Variable Category	System Demands & Storage Targets
Metric/Parameters	Daily load profile (L_t, kWh), Battery size (S_batt, 150 to 200 kWh)
Role in Simulation & Calculations	Represents target variables to evaluate system autonomy metrics.