“Eco-Fly Melodia: Intelligent Living. Infinite Energy.”

“Eco-Fly Melodi” is a scalable, growable, and adaptable modular system that integrates energy generation, sustainable living, and multifunctional infrastructure into a unified architectural and technological solution. The system is based around a central parabolic mirror structure with a rotatable core and attachable modules that serve multiple functions: energy towers, living accommodations, floating platforms (living module as well as), agricultural hubs, and community spaces, living module and infrustructure energy tower pavilion. Eco-Fly Melodia is a community-led renewable energy system designed for rural self-sufficiency. Its innovative design couples a highly efficient photovoltaic production system with a kinetic energy storage mechanism that acts as a “battery,” while integrating interactive artistic features. Locally accessible materials are used throughout, empowering the community to construct, maintain, and eventually replicate the system independently.

Our proposal introduces a visionary concept:

“Eco-Fly Melodi” adaptive solar modules, an infrastructure system that synthesizes solar energy generation, water harvesting, and modular architecture into one transformative design. The core element is a rotatable parabolic mirror structure that not only powers the site but anchors diverse land-based and floating functionalities such as housing, agriculture, public gathering spaces, and ecological restoration areas.

The architectural design draws deep inspiration from traditional Fijian bure structures, which reflect the indigenous architectural heritage of Fiji. A bure is a thatch-roofed, timber-framed dwelling constructed using locally sourced, sustainable materials and arranged in communal clusters. These structures are known for their elevated platforms, natural ventilation, and adaptability to the tropical climate. Our design translates the cultural principles of the bure—communal living, climatic responsiveness, structural simplicity, and symbolic centrality—into a futuristic and resilient energy architecture.

Much like the central post of a bure, our modules feature a central technical spine—a rotatable mirror mast—which becomes both the literal and symbolic anchor of each unit. The modularity reflects traditional village planning where structures are independent yet interdependent, adaptable yet connected. Roof structures echo the wide, overhanging forms of traditional thatch, reinterpreted here in reflective and solar-active materials. Public and communal uses—shaded markets, classrooms, kitchens, storytelling spaces—are embedded into the architectural vocabulary.

The primary design material palette includes local wood and bure material, steel structural supports, and solar panels etc. These materials are chosen for durability, lightness, and resistance to environments, ensuring long-term performance in the Fiji climate.

At the center of each unit is a mechanically kinetic-rotatable parabolic mirror that tracks the sun, optimizing solar concentration. Beneath it, a technical core (radius approx. 50 cm) houses infrastructure systems: electrical cabling, piping, energy storage, and solar-thermal technology. Surrounding this, modular elements may be added to serve multiple purposes depending on community needs: classrooms, event spaces, shaded markets, agricultural greenhouses, kitchens, or accommodations.

These structures are scalable and flexible. They can function as individual micro-units or be aggregated into urban-scale networks that grow as demand increases. Like a wearable garment, the structure "dresses" itself differently based on function: standalone pavilions, two- or three-story living units, or floating modules for climate resilience.

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Community experience is at the heart of the design. Modules are intended to be co-owned, co-maintained, and co-programmed by local users. Their configurations provide shade by day, ambient light by night (through LED arrays powered by stored energy), and serve as inclusive, safe public spaces. Rainwater collection from the mirror's central apex supports drinking water storage and irrigation.

The design blends energy independence, community empowerment, and adaptability, creating a circular economy at the site level. The integration of art, energy, infrastructure, and social architecture provides a multi-functional response to Fiji's environmental, economic, and cultural context.

A. Adaptable and Scalable Modular Design

A planar parabolic mirror structure can be used in various configurations, including as a pavilion by itself, wearing living space module on ground or on water or a multi-functional social space when they comes together with different amount, scales and variants.. It can be scaled to accommodate varying sizes, dimensions, and energy requirements. This adaptability ensures that the system can serve diverse functions, from a tourist accommodation to local community spaces, vegetable cultivation areas, or recreational spaces. Version of living space module can provide local economic and job opportunity for local community as well as floating villa version that can be designed with A planar parabolic mirror structure.
Briefly; A planar parabolic mirror structure can be wearable by living modular structure to create variants of module instead to provide only energy tower by itself. Multifunctional idea can be provable with many different living, or energy tower or pavilion version.

Living Modules Version: The design incorporates living space modules with two floors. The ground floor serves as a public area with shading, offering private entrances. The first floor is dedicated to living space, while the second floor can serve as a technical support area, recreational space, or pool, depending on future requirements.

Growable and Movable Structures: The system's modularity means it can be expanded, reduced, or relocated based on changing needs, making it ideal for evolving environments. It can grow in both size and function, ensuring that future requirements can be easily incorporated into the design.

B. Night Activation & Public Engagement

"Eco-Fly Melodi" adaptive solar modules structures are also cultural and social spaces. At night, LED elements embedded in the **underside of the parabolic mirrors** create ambient light, enable visual storytelling or projection mapping, and define vibrant social areas for events, performances, and gatherings—entirely powered by the stored solar energy of the day.

C. Adaptability and Growth Potential

The entire design ethos is centered on adaptability:Modules can be scaled vertically or horizontally, structures can be grouped or isolated, units can adapt to land or water environments. The same core mirror technology can be reconfigured to suit remote islands, disaster-relief housing, energy farms, eco-resorts, or urban extensions.

D. Symbolism and Visual Language
The “Eco-Fly Melodi”concept is visually compelling—its a planar parabolic mirror reads as a futuristic crown or umbrella, evoking both elegance and technological prowess. The modules’ ability to be **“dressed” or “worn”** onto the infrastructure core mirrors the versatility of fashion, creating an architecture that feels alive, dynamic, and responsive.

E. Summary & Impact
The “Eco-Fly Melodi” is not merely a only energy tower—it is an evolving system. It can:

Can be livable module, power entire islands, public space, floatable cabana version, providfe a economy and local job oppourunity for local community, can be independence community space, house tourists or displaced communities, Grow food, Host events, Adapt to future technologies and energy demands.

With its integrated core and modular ***“dress-like”*** adaptability, **The “Eco-Fly Melodi” proposes a new paradigm in infrastructure and habitation: clean, flexible, expandable, and human-centric.**

F. Photovoltaic Production Focus: At the heart of the energy generation is a parabolic mirror constructed from aluminum (5 m in diameter) that concentrates sunlight onto a high-efficiency photovoltaic panel (approximately 1×1 m) installed at its focal point. This photovoltaic system is the primary energy producer, converting concentrated solar radiation into electricity. Additionally, the mirror is designed with integrated gutters, so that rainwater is channeled into a cistern within the foundation, thereby supporting local water conservation.

Kinetic Energy Storage as a Battery: The kinetic subsystem functions solely as an energy storage device.

Two configurations are offered:
• **Option A (Primary Configuration)**: Two metal flywheel disks—each with a 3-m radius—rotate at 150 rpm. Each disk is ballasted with locally sourced earth (loaded in annular casings) to store approximately 5 kWh of energy. For this configuration, detailed calculations show that each disk requires roughly 16.2 tonnes of effective mass concentrated near the rim, amounting to a total of about 32.4 tonnes. The disks are arranged in counter-rotating pairs to cancel out forces and vibrations.

• **Option B (Alternative Configuration)**: Four metal flywheel disks of the same dimensions operate at 200 rpm. Here, each disk needs to store about 2.5 kWh, requiring roughly 4.56 tonnes of mass concentrated near the rim. Arranged in counter-rotating sectors, this configuration totals approximately 18.24 tonnes while achieving the same overall storage capacity of 10 kWh.

In both cases, the kinetic system is mechanically coupled to a generator/alternator via low-friction bevel gear assemblies and double-cone bearings. An electric motor is used both to accelerate the disks initially and, during deceleration, as a generator to convert the stored kinetic energy into plugand-play electricity. Interactive artistic elements further enhance the installation. As the flywheels rotate, an integrated mechanical carillon—comprising wooden chimes mounted on the disks that engage with a rotating comb—produces melodic tones that vary with the speed of rotation.

At the same time, strategically positioned LED lights around the reflective parabolic mirror create dynamic light plays during dusk and nighttime, turning the installation into a captivating audiovisual artwork that celebrates local ingenuity.

2. Technical Narrative

Kinetic Energy Storage System

Option A – 2 Disks (150 rpm):

• **Disks:** Two metal flywheel disks, each with a 3-m radius.
• **Rotational Speed:** 150 rpm (i.e., 2.5 rps, corresponding to approximately 15.71 rad/s).
• **Energy Requirement:** Each disk must store 5 kWh ≈ 18×10^6 J.
• **Calculated Mass:** $m = (2 \cdot E) / (R^2 \cdot \omega^2) = (2 \times 18 \times 10^6 \text{ J}) / (9 \times (15.71)^2) \approx (36 \times 10^6 \text{ J}) / (9 \times 246.7) \approx (36 \times 10^6) / 2220.3 \approx 16216$ kg (≈16.2 tonnes per disk).
• **Total Mass:** Approximately 32.4 tonnes.
• **Configuration:** The two disks are arranged in contrarotating pairs to cancel net angular momentum, reducing vibration and mechanical stress.

Option B – 4 Disks (200 rpm):

• **Disks:** Four metal flywheel disks, each with a 3-m radius.
• **Rotational Speed:** 200 rpm (≈3.33 rps, or about 20.94 rad/s).
• **Energy Requirement:** Each disk must store 2.5 kWh ≈ 9×10^6 J.
• **Calculated Mass:** $m = (2 \times 9 \times 10^6 \text{ J}) / (9 \times (20.94)^2) = (18 \times 10^6 \text{ J}) / (9 \times 438.6) \approx 4559$ kg (≈4.56 tonnes per disk).
• **Total Mass:** About 18.24 tonnes.
• **Configuration:** The four disks are arranged in counter-rotating sectors to cancel forces and vibrations.

Solar Concentrator and Orientation System

• **Parabolic Mirror:** A planar parabolic mirror fabricated from aluminum, 5 m in diameter, providing a projected (focal) area of roughly 19 m^2. This mirror concentrates sunlight onto the high-efficiency photovoltaic panel.

• **Photovoltaic Panel:** A 1×1 m panel positioned at the focal point, converting concentrated solar energy directly into electricity.

• **Dual-Axis Orientation Mechanism:** The mirror is mounted within a decorative spherical joint that conceals its orientation apparatus:

o **Rotating Platform (Horizontal Movement):** A platform rotates about a vertical axis by means of a toothed wheel and a reduction gearbox (typically 1:10–1:20), allowing precise horizontal adjustments.

o **Cable-Based Tilt Mechanism (Vertical Movement):** The mirror is connected through two steel cables at its top and bottom that wind onto precision winches (with diameters set approximately D/10 to D/20, where D is the sphere's diameter) for gradual, precise tilt adjustments.

o Sun-Tracking: A control unit employs encoders, position sensors, and sun sensors (similar to cubesat technology) to continuously monitor the sun's position and coordinate the dual-axis movements for optimum solar tracking.

Integrated Water-Channeling System

The parabolic mirror is also designed to harness rainwater. Integrated gutters on the mirror capture rainwater and channel it into a cistern built into the structure's foundation. This cistern supports local water conservation and provides an auxiliary water source.

Interactive Artistic Features

• Mechanical Carillon: A system of wooden chimes mounted on the rotating flywheels engages with a rotating comb, generating melodic tones that vary with the speed, offering an auditory signature to the system's mechanical operation.

• LED Light Plays: LED lights, strategically installed around the reflective parabolic mirror, create dynamic visual effects that change with the mirror's movement and the sun's position, complementing the auditory carillon to deliver an immersive audiovisual experience.
System Inputs & Outputs

• Inputs: • Sunlight (concentrated via the parabolic mirror) • Kinetic energy stored in the flywheels (serving as an energy battery) • Rainwater (collected via the mirror's channels)
• Outputs: • Electricity (generated by the photovoltaic panel and recovered from the kinetic storage system via the generator) • An audiovisual interactive display produced by the carillon mechanism and dynamic LED light plays.

3. Prototyping and Pilot Implementation Statement
The prototyping phase will include developing scaled models of both the kinetic storage system and the mirror orientation apparatus. Local workshops will be carried out to train community members in metal fabrication, earth ballasting, and the assembly and calibration of the drive and control systems—including precision winches and sun sensor integration for optimal solar tracking. Once these prototypes are refined, a full-scale demonstration installation (offering either the 2-disk or 4-disk configuration) will be deployed in Fiji, ensuring that the design is fully replicable with available local resources.

4. Operations and Maintenance Statement
Eco-Fly Melodia is designed for straightforward, community-based operation and maintenance:
• **Operation:** Operators will use an intuitive control panel to monitor flywheel speeds, generator
output, and mirror orientation. Integrated sun sensors allow real-time tracking of the solar position, while the water-channeling system is continuously monitored.
• **Maintenance:** Regular inspections will be performed on the mechanical drive systems, ballasted flywheels, and precision winches. Routine cleaning of the aluminum mirror, LED assemblies, and gutters will ensure optimal performance. The cistern and related watercourse elements will also be maintained to guarantee effective rainwater collection.
• **Training & Support:** Community-led workshops and thorough open-source documentation will ensure local technicians are well-equipped to manage repairs, perform system upgrades,

and retain operational knowledge over the long term.

5. Environmental Impact Assessment

The design emphasizes sustainability and is intended to have minimal environmental impact:
• **Low-Impact Materials:** The use of recyclable metals for the disks, locally sourced earth for
ballast, and sustainably produced aluminum reduces the overall environmental footprint.

• **Water Integration:** The integrated water-channeling system captures rainwater effectively,
redirecting it into a cistern that supports local water needs and minimizes runoff and erosion.
• **Low-Impact Construction:** The semi-buried concrete housing minimizes disruptive excavation, while excess soil is repurposed to form natural hillocks that blend the installation into the surrounding landscape.
• **Biodiversity and Monitoring:** Native vegetation will be preserved around the installation, and regular community-led environmental monitoring will address any unforeseen impacts on soil, water, or habitat.

Conclusion
Eco-Fly Melodia presents a comprehensive renewable energy solution that focuses primarily on highyield photovoltaic production. The parabolic mirror, with its integrated dual-axis orientation and waterchanneling features, directs sunlight onto a high-efficiency solar panel to generate electricity. The kinetic energy storage system—configured as either two disks operating at 150 rpm (totaling approximately 32.4 tonnes) or four disks at 200 rpm (totaling approximately 18.24 tonnes)—functions solely as an energy reservoir rather than a production device. By integrating a captivating mechanical carillon and dynamic LED light displays on the mirrored parabolic surface, the system also provides an immersive audiovisual experience. Constructed entirely from locally accessible materials and designed for community assembly and maintenance, Eco-Fly Melodia offers a scalable blueprint for achieving energy independence and sustainable development in Fiji and similar rural settings.

Keywords: Renewable Energy, Photovoltaic Production, Kinetic Storage, Dual-Axis Orientation, Sun Sensors, Mechanical Carillon, LED Light Play, Rainwater Channeling, Community Autonomy, Sustainable Design, LAGI2025 Fiji