ThermaVault Synopsis

In many underserved communities around the world, access to reliable electricity and affordable cooling systems remains out of reach. The absence of proper refrigeration and temperature regulation causes food and medicine spoilage, discomfort during heatwaves, and even life-threatening conditions such as heatstroke. ThermaVault seeks to address this challenge by providing a low-cost, solar-powered thermoelectric cooling solution that is portable, energy-efficient, and easy to maintain.

At its core, ThermaVault uses a Peltier module based on the Peltier Effect, a phenomenon where an electric current creates a temperature difference across the module, producing a cold side and a hot side. The cold side cools the insulated chamber, while a heat sink and fan on the hot side efficiently dissipates excess heat. A microcontroller, equipped with temperature sensors, continuously monitors and adjusts power to maintain the desired internal temperature.

This system can keep perishables, food, or medicine at safe temperatures in areas without stable electricity, offering a clean, sustainable alternative to traditional compressor-based refrigeration. It can be powered directly by solar panels or a small battery pack, making it ideal for remote or off-grid environments.

With an estimated total cost of just ₹2,000–4,000, ThermaVault is designed to be simple, modular, and affordable. It reduces dependence on fossil-fueled power, promotes renewable energy adoption in low-income areas, and improves daily living conditions—all while remaining compact and accessible for anyone to use, repair, or replicate.

ThermaVault Working Details

The ThermaVault prototype functions as a compact, solar-powered cooling system designed for small, insulated enclosures. It operates on the Peltier Effect, using one or more Peltier modules that, when powered, create a temperature gradient—one side becomes cold, and the opposite side becomes hot.

The cold side of the module is attached to a metal plate or thermal conductor that cools the internal air of a thermally insulated box, while the hot side is fitted with a heat sink and fan to expel heat efficiently. Proper thermal insulation is critical to minimizing energy loss and maintaining consistent temperatures inside.

A microcontroller (such as an Arduino UNO/NANO or ESP32) manages temperature regulation. Sensors like the DHT11 monitor the temperature within the box and adjust power to the Peltier module based on set thresholds. If the temperature rises above the desired range, the system automatically increases cooling power; when it stabilizes, it reduces output to conserve energy.

Power is provided by a lithium-ion battery, which can be recharged through a solar panel, ensuring continued operation even in areas without grid access. The system is designed for low power consumption (20–40W average) and silent operation, suitable for preserving food, medicines, or other temperature-sensitive materials.

Implementation involves: assembling the Peltier, heat sink, and fan system; integrating sensors; programming temperature control logic; optimizing insulation; and testing the cooling efficiency. The result is a lightweight, modular, and sustainable cooling device tailored for real-world use in resource-limited settings.