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Design and Development of a Portable Solar-Powered Refrigerator Using Thermoelectric Cooling for Off-Grid Applications

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Abstract: *Power failures, unavailability of rural infrastructure, and the use of mobile cooling devices have required sustainable refrigeration. This paper describes the development and design of an "Anywhere Fridge," a portable, solar-powered, thermoelectric off-grid refrigerator. The device uses solar energy to drive a Thermoelectric Cooling (TEC) module (TEC-12706) coupled with battery storage technology, and it is suitable for off-grid and emergency use. The design is portable, collapsible, and does not use traditional refrigerants, providing an environmentally friendly solution. The unit's central component is a heat sink, temperature sensors, battery, and two Peltier plates powered by a DC power supply from a photovoltaic (PV) panel. A detailed methodology outlines the solar energy converted into electricity and controlled with a proposed power-sharing controller. Theoretical analysis was supplemented with experimentations, and a temperature drop of 13.5°C was found in 7 minutes. Cost analysis indicates a total development cost of ₹12,345, and the system is therefore cost-efficient. Applications span medical transport, electronics cooling, and rural food preservation. The system's advantages include silent operation, no moving parts, and reversibility (cooling/heating). This paper discusses limitations such as low cooling load capacity and outlines future improvements, including dual-TEC integration and intelligent power regulation. The Anywhere Fridge emerges as a promising innovation for portable refrigeration, contributing to sustainable living and energy-independent cooling technologies.*

Keywords: Thermoelectric Cooling, Solar-Powered Fridge, Peltier Module, Portable Refrigerator, Off-Grid Applications, Renewable Energy

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