

Mini Hydroponic Generator: Integrating Vertical Farming with Micro-Scale Hydroelectric Power Recovery

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Abstract:

The Mini Hydroponic Generator is a vertically oriented closed-loop system that integrates soil-less plant cultivation with micro-scale hydroelectric power recovery. A DC submersible pump circulates a nutrient-rich aqueous solution from a base reservoir to the apex of a vertical PVC tower, where water trickles downward through a series of net pots containing plant seedlings. Essential macro- and micro-nutrients are delivered directly to exposed root systems, promoting accelerated growth and high water-use efficiency. The descending return flow is directed through a micro-hydro turbine generator, which converts the kinetic energy of the falling water column into usable electrical energy. This generated power is conditioned and used to drive an LED status indicator and interface with an Arduino Uno microcontroller that monitors system parameters in real time. The project demonstrates a proof-of-concept for energy-integrated agriculture, combining principles of fluid mechanics, renewable energy harvesting, precision nutrient delivery, and embedded systems into a single compact platform. The system is low-cost, scalable, and replicable, making it well-suited for urban farming, educational laboratories, off-grid agricultural installations, and sustainable food production research. This paper presents the complete system architecture, component selection rationale, working principle, methodology, results, and future development roadmap for the Mini Hydroponic Generator.

Keywords:

Vertical Hydroponics, Micro-Hydro Turbine, Nutrient Film Technique, Arduino Uno, Renewable Energy Harvesting, Urban Farming, Closed-Loop Recirculation, Embedded Systems, Sustainable Agriculture, Energy Recovery.