



HARVESTING HYDROPOWER FROM URBAN BUILDINGS DURING RAINFALL

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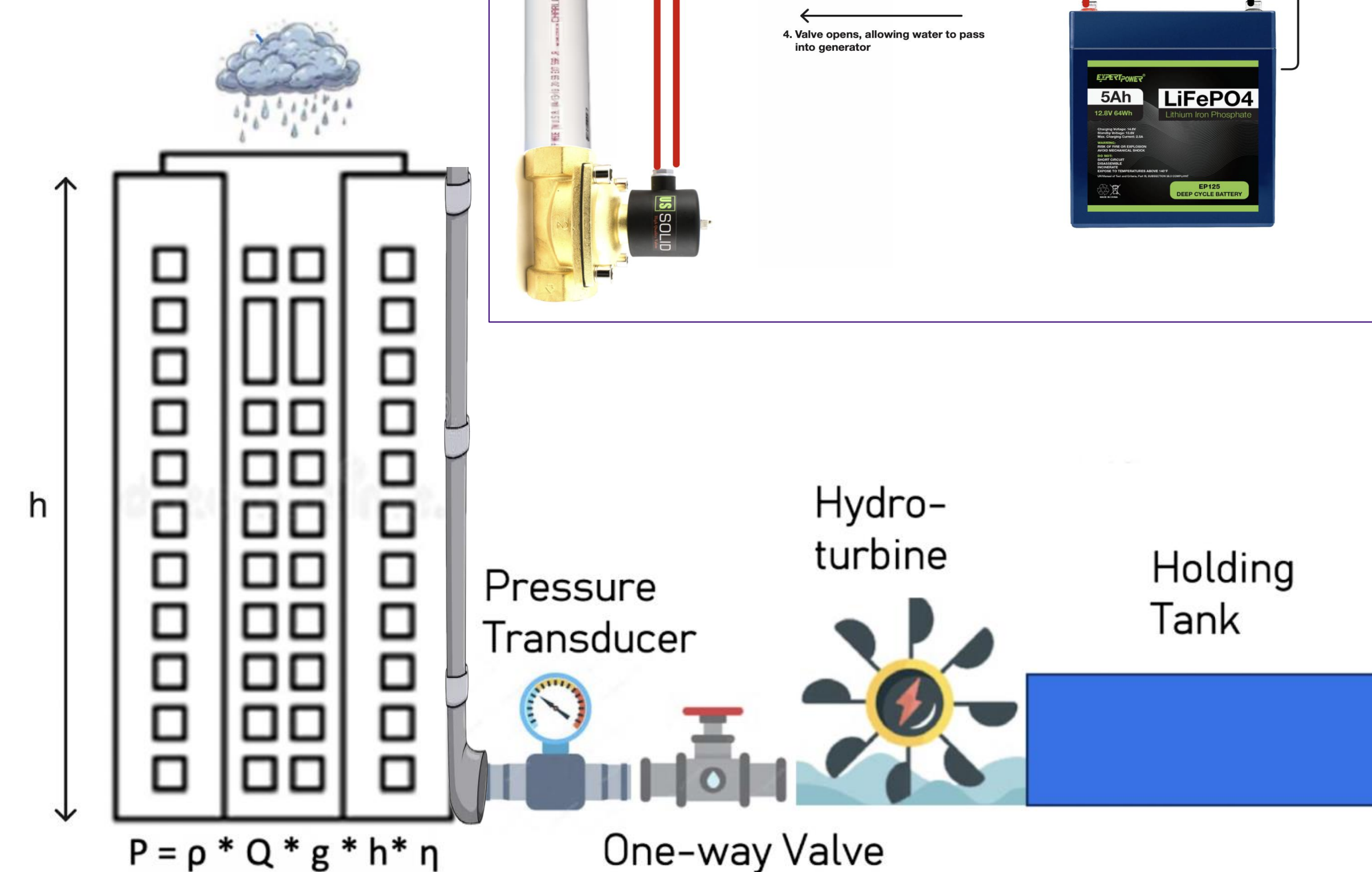
Seattle City Light

Introduction

Rainwater collected on the rooftops of tall buildings is a potential source of hydropower at the ground level.

- During rainfall, drainage pipes collect water, building hydrostatic pressure at the ground level.
- Water in pipes becomes pressurized, running a turbine at ground level.
- The turbine will run while the hydrostatic pressure stays at an operating level.
- Electricity generated is stored in a battery and can be used to support systems during power outages.

P = Power generated
 ρ = Density of water
 Q = Flow rate
 g = Gravity
 h = Elevation
 η = Turbine efficiency



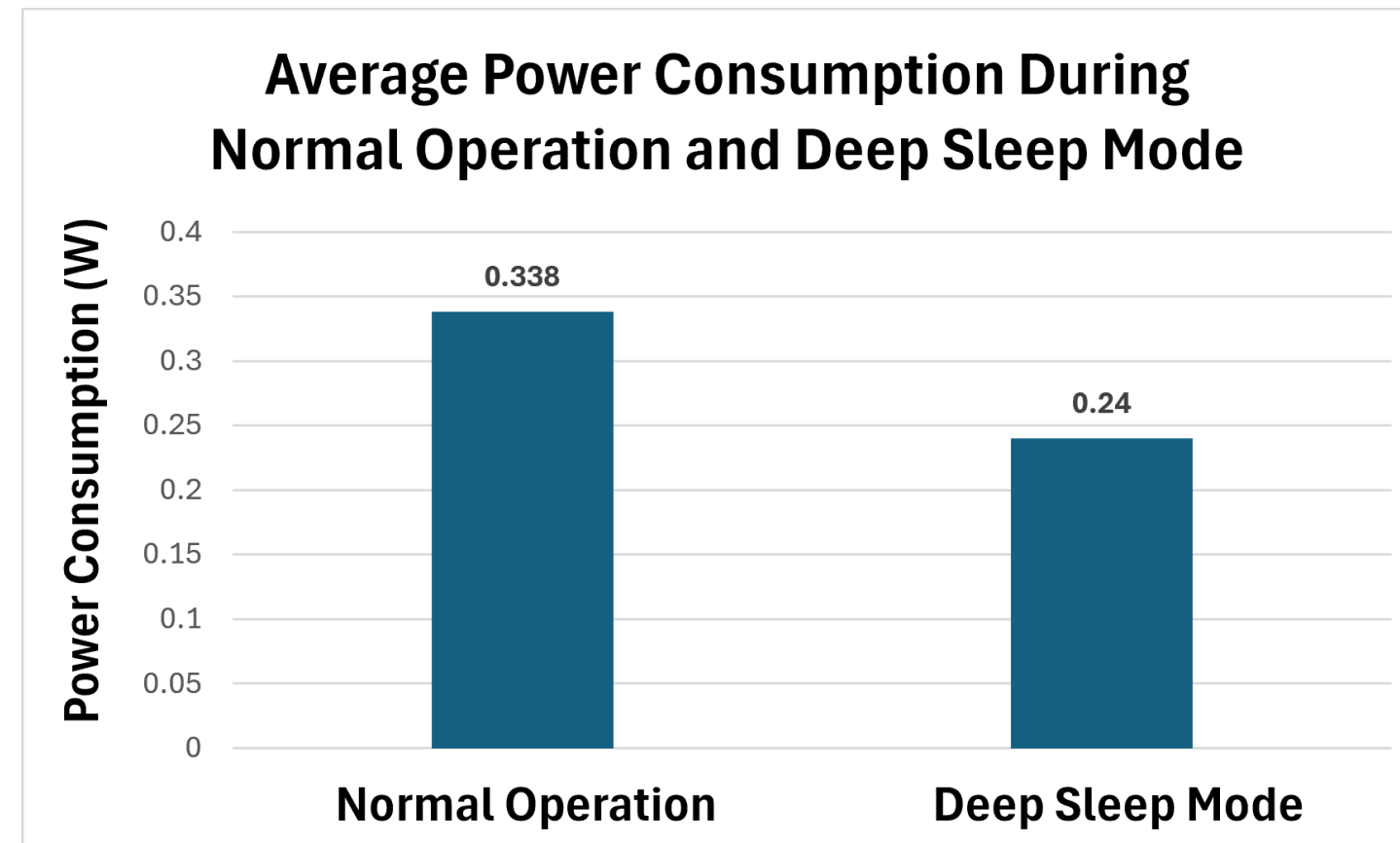
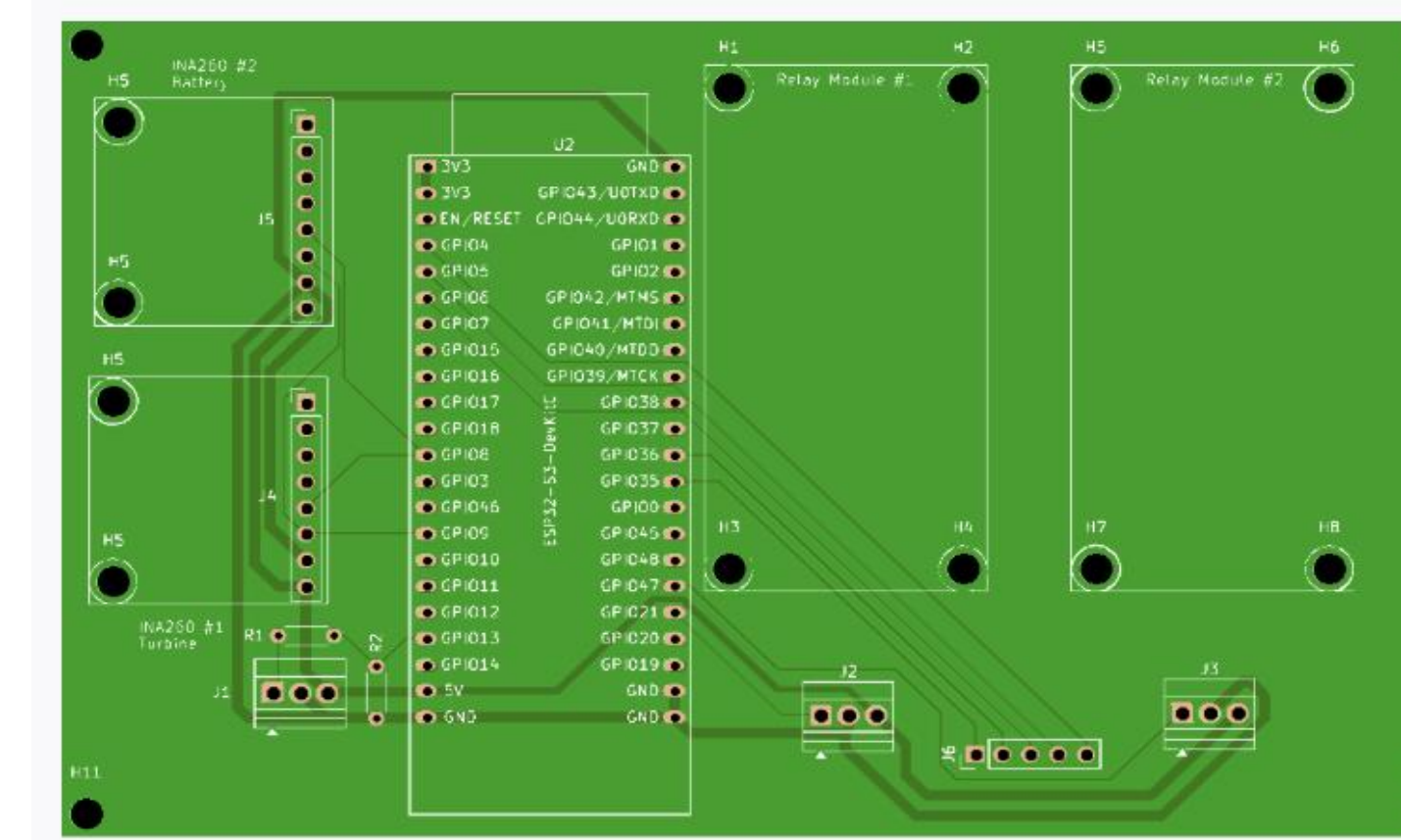
Objectives and Requirements

Design and test the feasibility of a compact hydroelectric system.

- **Store generated energy:** Capable of producing energy for small and large-scale buildings, the system stores power for future use.
- **Operate Autonomously:** Develop an automated control system that checks pressure and controls water release without human intervention.
- **Support Sustainable Urban Infrastructure:** Prove that buildings can support both water management and renewable energy generation.
- **Develop a scalable prototype:** Develop a prototype adaptable for residential and commercial buildings.

Implementation and Results

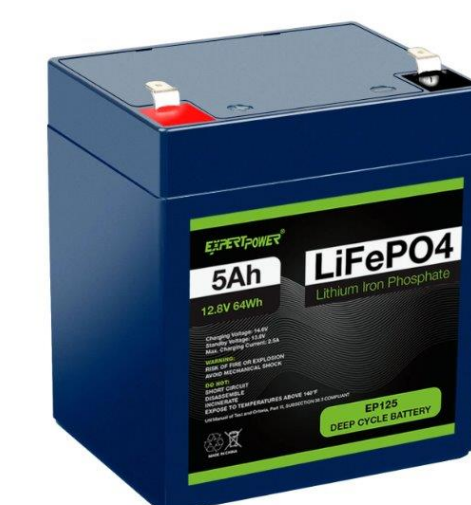
- **Control:** An ESP32 manages logic operations, including data acquisition, valve control, and energy calculations.
- **Deep Sleep Mode:** The system enters deep sleep mode when water head is low to conserve power
- **Valve Control:** The valve is controlled using a relay, which opens the valve at specified PSI.



- **Power Consumption:** The electrical system consumes approximately 3W of power during operation and ~1mW in deep sleep mode.
- **Data Acquisition:** Voltage, power, and current are measured in one second intervals during operation.

Modules

Battery and Power System: Supports stable power to all components and enables charging



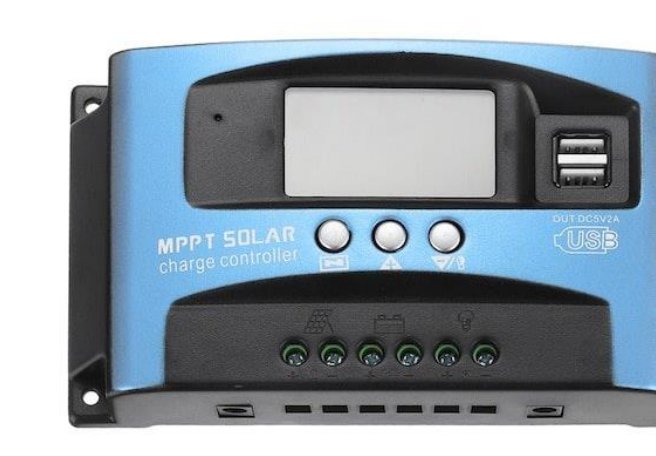
12V Battery



DC-DC USB Converter



36W DC Turbine

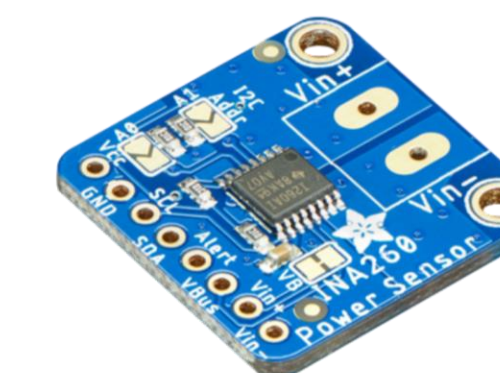


MPPT Charge Controller

Control and Sensors: Monitors current state of system and operates other modules



ESP32-S3-Devkit



Adafruit INA260



15 PSI Pressure Transducer

Water flow Control: Directs and controls the flow of water during generation and bypass



Power Relay Module



Ball Turn Valve

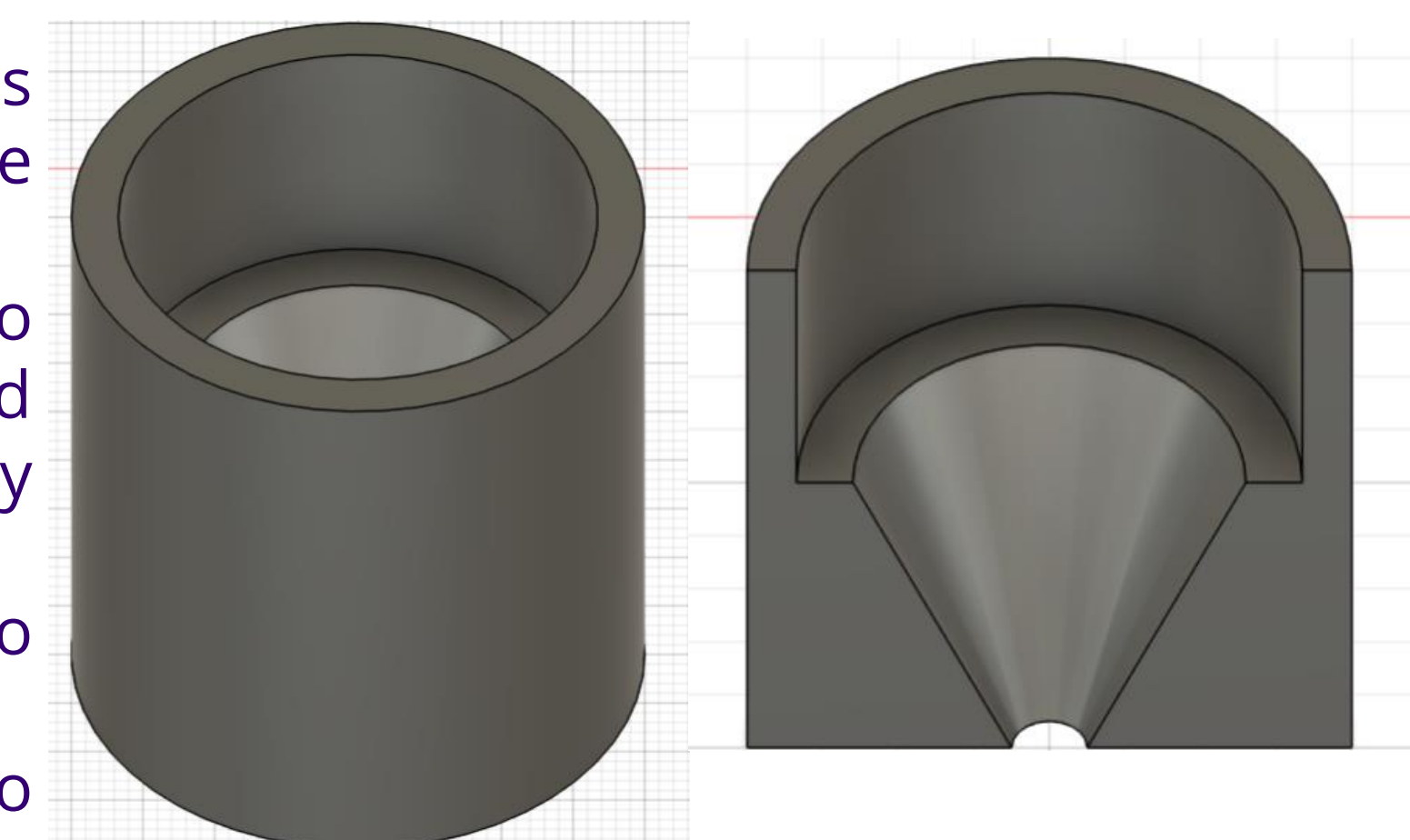


Mechanical Bypass Valve

Nozzle Design and Development

Increases water velocity, thus increasing power output.

- Pressure created by head was previously lost due to turbine characteristics.
- Nozzle allows the system to function with less flow, instead maximizing the kinetic energy of the impeller turbine.
- The nozzle fixes the pipe to the turbine.
- A funnel system is used to decrease output width to 0.2 inches.



Future Optimization

- **Graphical User Interface (GUI):** Mobile application development should be investigated to enable users to check power generation via a device.
- **Hydro Turbine Development:** In-house turbine development may lead to better efficiency, allowing for a lower volume of water to be used.
- **Focusing on Scalability:** A system suitable for use on single-story buildings should be developed to allow for a lower head.

Conclusion



The feasibility of generating and storing electrical energy from rainwater collected by rooftops was shown. Hydrostatic pressure was used to drive a turbine, creating energy, and thus charging a battery. With further optimization and large-scale implementation, the system can achieve greater efficiency and generate significantly more power for supplemental and emergency energy applications in urban environments.

References and Acknowledgements

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