Address growing need for renewable and reliable power in storm-related power outages
Goal

Create in-home renewable energy from storm events to balance storm-related power losses
Final Concept

Power battery with rooftop gutter-guided rainwater (microgrids) with water harvesting tank
Concept Diagram

- Typical roof gutter
- Typical roof downspout
- Water Collection Tank
- Turbine
- Generator
- Power output (battery)
Technical Design

Pelton Wheel
Outsourced solidworks design with edits

Generator
Permanent magnet commutator motor mounted to turbine
Technical Design

Motor Calculation

\[ v_t = k \omega - i R_A \]

\( R_A = \text{Armature Resistance} \)

Fluid Calculation

\[ \tau = \frac{\rho ghQ}{\omega} \]

\( Q = \text{water flow rate} \)
Technical Design: Theoretical Data

Plot of Torque vs. omega

- Resistance 1
- Resistance 1/3
- Resistance 3
- Resistance 1/2
- Height 3
- Height 2
- Height 2
- Height 0.5

T(Nm) vs. omega(rad/s)
Catchment System

Wall mounted tank
Pressure gauge for mechanical metering
Potential app for smart home control
Fluid Calculations

\[ v = C_v \sqrt{2gh} \]

Mainly dependent on height of water

\( C_v \) is dependent on parameters of water exiting
Fluids Proof of Concept

Assumptions

- 1 in/hr rainfall
- 2700 ft² roof area
- 35 ft roof
- 0.8 efficiency

\[ P_{th} = \rho qph \]

Water Collected
6.4 m³

Output Power
15.1 Wh
Experimental Setup

Goal
Determine actual performance of turbine

Measured
Water velocity (height, distance, flow rate), resistance
Voltage

Problems
Motor Protection
Varying conditions (wind)
Experimental Results

Max Power output recorded:

0.82 W

Proof of concept; scaled up
Results

Height 1 meter
Resistance 0.33 Ohms
Power 8.95 W
Environmental Benefits

Rooftop Harnessing
Ability to shift gutter flow away from streets or to harvest for use

Potential System Carbon Offset
0.0026 lbs CO$_2$ produced per watt-hour via portable gas generator

Replacing a gas generator saves 131 lbs CO$_2$ per house per year
Social Benefits

Safety through enhanced communication (wifi, phones, etc.)

Potential greywater capture and reuse

Enhanced Interconnectivity
Target Market

Rural areas
Developing Countries--PAYGO
Individual Homeowners

Data from Parents of Duke Students:
91.5% in owned home
74.6% willing to mount system
Expanded Market

Developing Countries

- Renewable and reliable
- Located at home - no need to travel long distances for small amounts of power
- Better than solar
  - Easier to fix
  - PAYGO
  - Cheaper
Business Plan

- Costs <$50 (61%)
- Observe rain data from other parts of the world
- Frequency of blackouts
- Subsidized by Duke Energy
- Modular design
Updated Prototype Costs

**Purchased**
- $95 motor (provided)
- $10 plastic mounting piece
- $3 15/64” drill bit
- $20 plastic rod

**Predicted**
- $5 cover for turbine
- $15 tank
- $5 PVC outlet
Conclusions

Larger scale
Cheaper bill of materials
Electrical control of catchment system
Financial Support