Power Generation through Recycled Materials

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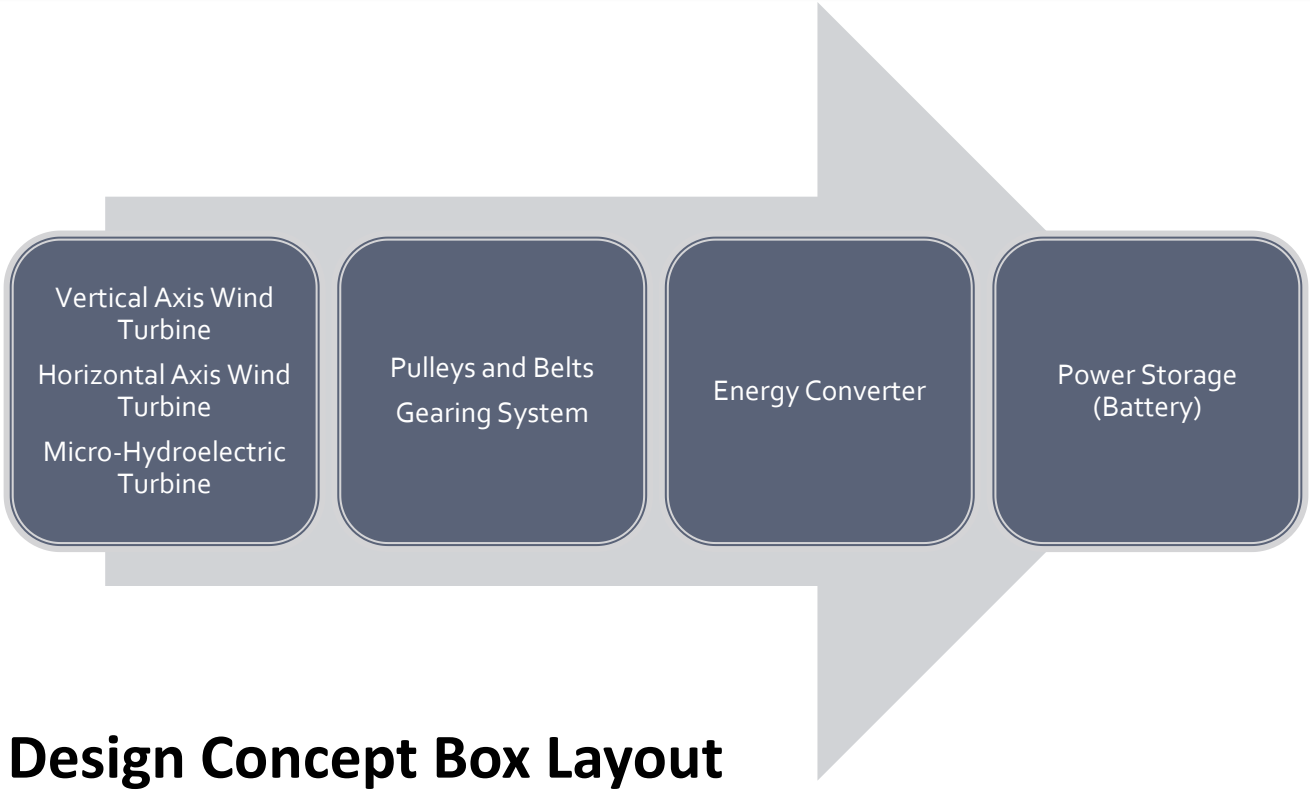
Sponsor: Cummins

Background Overview

- **Problem Statement:**
  - Design and construct a power generation device that implements the use of a renewable energy source and is composed entirely of recycled materials
- **Objectives:**
  - Must generate 100 W•h/day
  - Must store 300 W•h
  - Output must be 12 V DC
  - Must sustain severe weather
- **Constraints:**
  - Must choose three different geographic locations
    - 100 km away from the ocean, 500 km away from each other
  - Final product must cost under $50

Design Layout

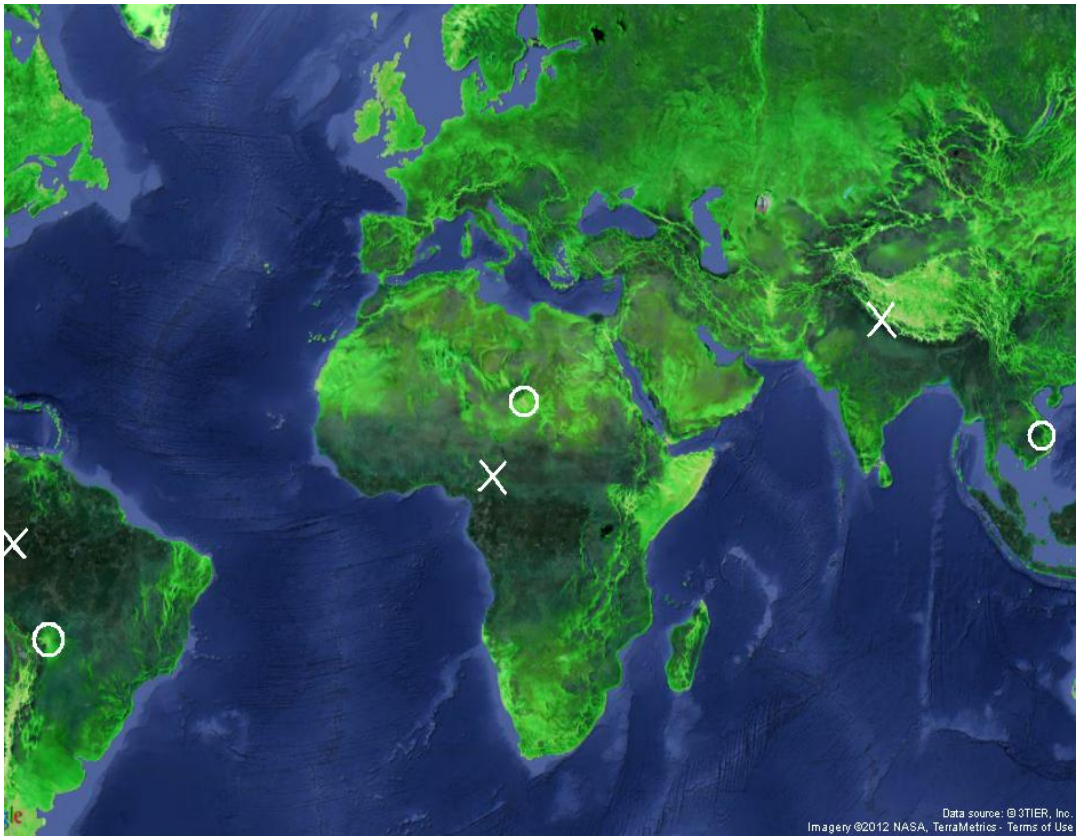


- **Design Concept Box Layout**
  - Energy Capture→ Speed Change→ Energy Conversion→ Battery Storage
  - Simplicity with 4 component layout

Geographical Locations

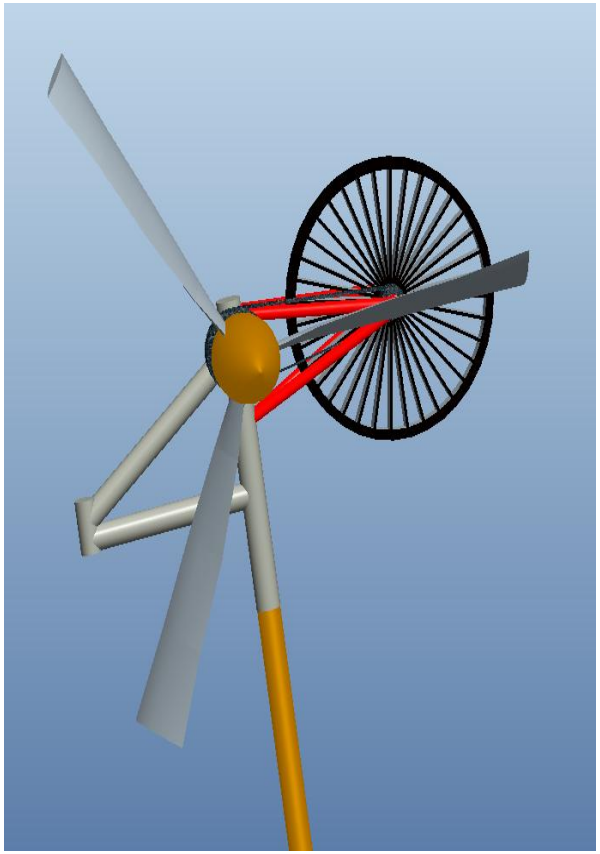
- **Wind Energy Locations**
  - **Faya-Largeau, Chad**
    - Average wind speed = 4.6 m/s ~ 10 m height
  - **Santa Cruz, Bolivia**
    - Average Wind = 3.9 m/s ~ 10 m height
  - **Sen Monorom, Cambodia**
    - Average Wind = 5.1 m/s ~ 10 m height

(An average of 4 m/s was used for calculations)

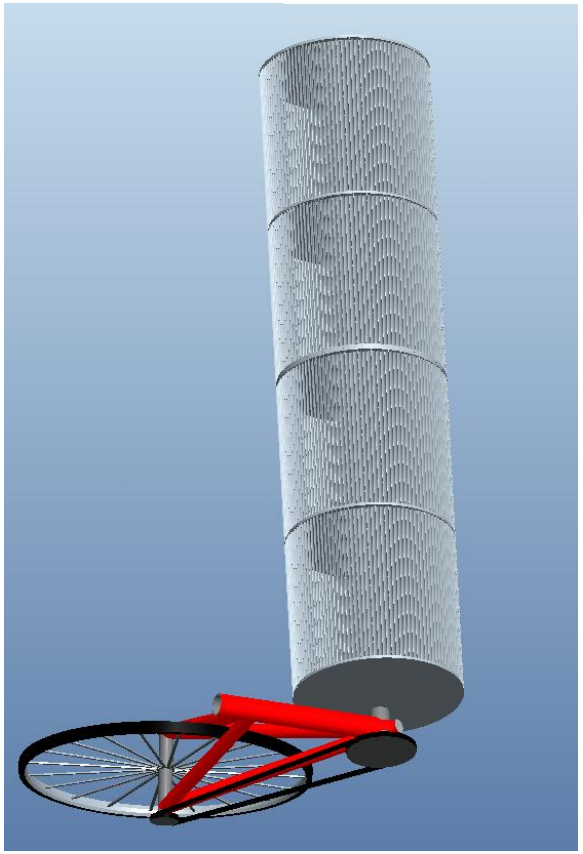


- **Water Energy Locations**
  - **Atrato River, Colombia**
    - Average Flow = $2.0 \cdot 10^6$ L/s
  - **Indus River, Pakistan**
    - Average Flow = $6.5 \cdot 10^6$ L/s
  - **Benue River, Cameroon**
    - Average Flow = $1.75 \cdot 10^5$ L/s

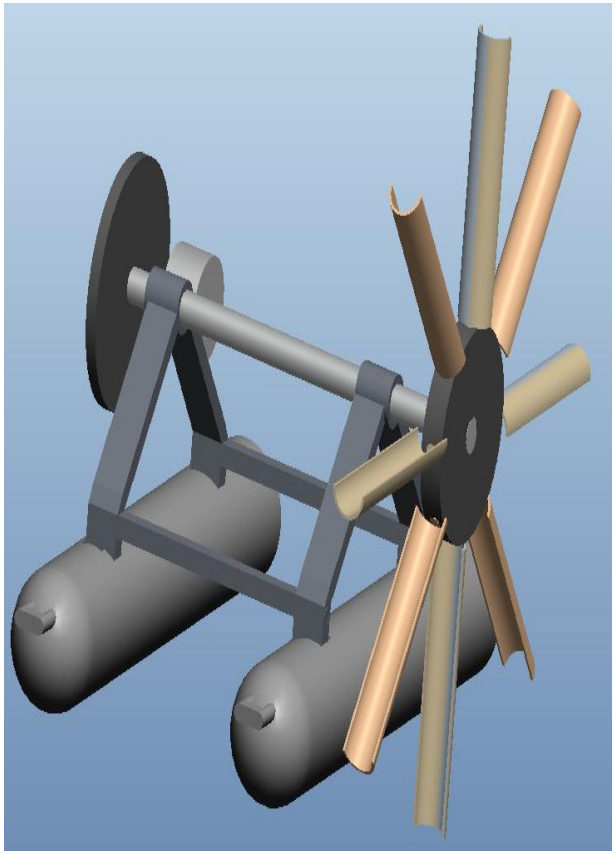
Building the HAWT, VAWT, Micro-Hydro



HAWT-Horizontal Axis Wind Turbine



VAWT- Vertical Axis Wind Turbine



Micro-Hydro Electric

Wind Design Specifications

VAWT

- **Drag based Savonius turbine**
- **Power coefficient**
  - **0.24**
- **2-Savonius blades**
  - 90° offset
- **Area of turbine (10W output)**
  - Minimum area: 1.56 m^2
  - Minimum cylinder diameter: 0.38 m
  - Minimum cylinder height: 2.5 m
- **Bicycle dynamo assembly**
- **Supporting structure**

HAWT

- **Lift based turbine**
- **Power coefficient**
  - **0.114**
- **3 – blade design**
  - 120° offset
- **Area of turbine (10W output)**
  - Minimum area: 3.29 m^2
  - Actual area: 3.58 m^2
  - Diameter of blade: 2.14 m
- **Bicycle dynamo assembly**
- **Supporting structure**

Construction of Horizontal Axis Wind Turbine Design

COMPLETED TASKS

- **Constructed turbine blades**
- **Assembled turbine**
  - Working area = 3.58 m^2
- **Refurbished bicycle**
  - Collected and cleaned ball bearings
  - Removed chain tensioner
- **Constructed supporting structure**
  - Model used by consumer slightly modified
- **Tested rated power on dynamo**
  - Obtained 6V and 3W on hand power

REMAINING TASKS

- **Decrease resistance of gearing assembly**
- **Reconstruct turbine**
  - Create lighter and slightly smaller blades
- **Testing**
  - Looking towards 2 or more dynamos, possibly alternator system

Testing of the Horizontal Axis Wind Turbine Design

PRELIMINARY TESTING

- **Stationary mounted testing (Wind speed ~ 4.5 m/s)**
  - Turbine blades were mounted at approximately 10 ft
  - Blades rotated when gearing assembly was unattached
  - Blades failed to rotate upon attachment of the system
- **Modifications**
  - Construction of lighter blades (thinner PVC)
  - Loosening of bicycle chain to provide less resistance
  - Angle adjustment of blades
  - Height may be increased to account for higher wind speeds

FUTURE TESTING

- **Dynamic automobile testing**
  - System will be mounted and attached to vehicle
  - Battery will be attached and discharged
  - Vehicle will be driven on empty parking lot at 4 m/s and various speeds
  - Multi-meter will be used to measure voltage and current

Pictures of Horizontal Axis Wind Turbine Design

Construction of Vertical Axis Wind Turbine Design

PROBLEMS

- **Mangled half-cylinders**
  - Recycle yard receives junk
- **2 - 55 gallon drums for Savonius VAWT design**
  - Adequate support structure unavailable for extreme weather
  - Only able to procure 1 drum in good shape

POSSIBLE SOLUTIONS

- **Employ plentiful pre-existing fan assemblies**
  - Excellent condition due to fan housing assembly
  - Lightweight, easy to support

Vertical Axis Wind Turbine

FUTURE PLANS

- **Complete research, design of new turbine system by weekend**
  - Turbines designed to push air, no previous research on reverse
- **Procure more turbines from recycle yard**
- **Time-allowing, begin construction in March**
  - Can be employed with existing gearing systems
    - Short build, begin testing
  - Focus on HAWT for wind powered

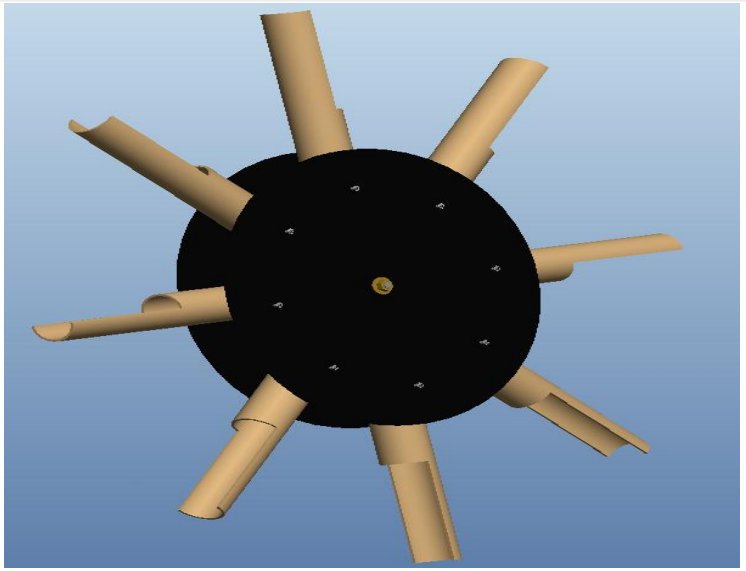
Pictures of Vertical Axis Wind Turbine Design

Construction of Micro-Hydro Turbine Paddle Wheel

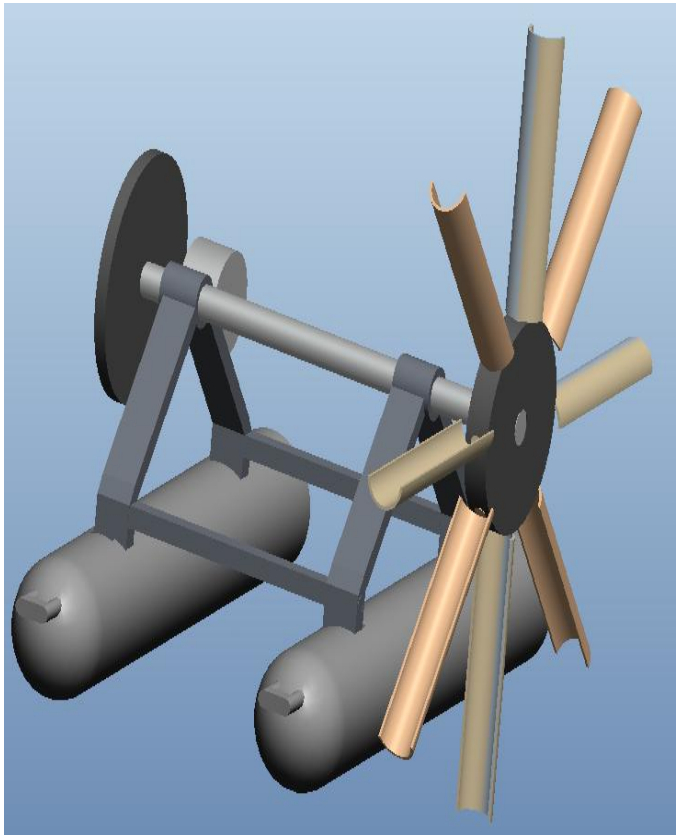
- **Paddle-Wheel**
  - Use indigenous bamboo to reduce cost and utilize locally abundant resources
  - Lightweight and holds up well in water
- **8 fins**
  - At least two are in contact with the water at all times

Prototype Considerations

- *Utilize 4'' PVC in place of Timber Bamboo*



Pictures of Micro-Hydro Turbine Design



Construction of Micro-Hydro Turbine

COMPLETED TASKS

- **Secured all raw materials**
  - e.g. bicycles, alternator, PVC(4 in. and 8in.), plywood
- **Paddle wheel**
- **Repaired Alternator**
  - Cleaned, new bearings, and voltage regulator

REMAINING TASKS

- **Complete machining of coupling shaft and paddle shaft**
- **Fabricate alternator bracket and belt**
- **Attach paddle wheel**
- **Permanently fix bicycles to PVC floats**
- **Seal PVC floats**
- **Test via boat pull or tidal shift**

Future Plans

- **Finish assemblies before end of February**
- **HAWT system modifications will be made and dynamic testing will be performed before the end of February**
- **Incorporate a safety for severe weather**
  - Redirection of turbine
    - Tail-fin will provide the redirection through attached mechanism
  - Waterproof micro-hydro turbine assembly
    - Employ circuit breaker in case of short-circuit
- **Biweekly teleconferences with Cummins representative Terry Shaw**

Questions?