NATURE'S POTENTIAL

Creating, Capturing, and Transmitting Energy Data from Nature

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Introduction

Creating Energy from Trees

Chemical Voltage Potential -

- Living trees move water, sap, and gas throughout their system: "Transpiration"
  - Capacitive Voltage

Inertia –

- If a tree sways, there is energy in its movement.
  - Kinetic Energy

Capturing Energy Data

Arduino IDE (Integrated Development Environment)

- Low power
- Easily adaptable
- Cost effective

Transmitting Energy Data

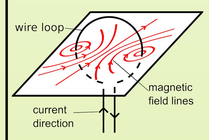
AWS (Amazon Web Services)

- Reliable
- Convenient
- Cost Effective

Methods

Energy Capture: Voltage & Current

1. Voltage Between Tree and Soil -
   - Cathode (+): Copper nail in tree trunk
   - Anode (-): Spike driven into ground



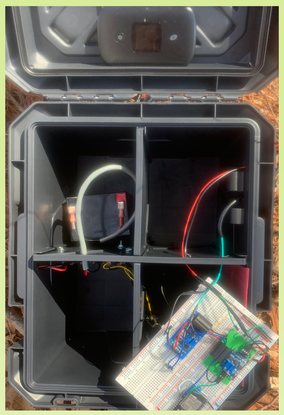
2. Dynamo: Current Driven by Tree Movement -
   - Magnet pulled through a coiled wire as tree sways
     - "Magnetic Flux" forces current in wire

Full data acquisition device

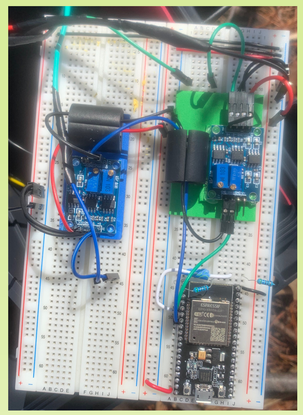
Close-up view of (+) and (-) tree voltage pins

Data Capture: Microcontroller Circuit

- 12v DC → 5v DC Arduino supply voltage
- Op-amp voltage boosters for incoming signals
  - Arduino ADC (Analog to Digital) conversion is inaccurate from 0-1mV range
- Mobile "hotspot" to keep Arduino connected to the "Cloud"
- MQTT (Message Queuing Telemetry Transport) communication with AWS to send collected data



Inside environmental housing unit

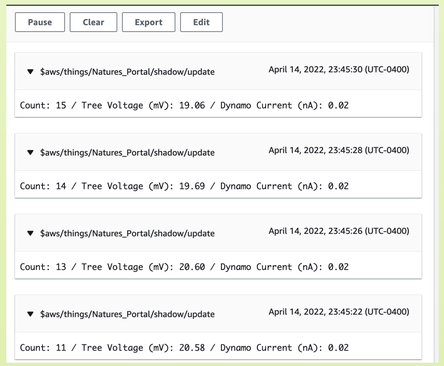


Close-up view of signal capturing circuit and Arduino (ESP32) microcontroller

Results

Mixed Success

1. Tree-Voltage
   - Consistent voltage between tree and ground made capture simple
2. Dynamo
   - Lack of sustained wind forced student to manipulate magnets manually
3. Data Reading
   - Arduino "analogRead()" function frustratingly inaccurate
4. MQTT upload to the "Cloud"
   - Data is often dropped in failed uploads



Display from AWS Server → Remotely Accessible

Future Direction

1. Current generator needs to be refined
   - Increase wire coils for higher current output
   - Reduce Area Footprint
   - Find an area with more wind potential
2. Incorporate sensors in data acquisition device
   - Collect sun light, wind speeds, temperature readings
3. Configure microcontroller code to receive commands from AWS
   - Allow remote control of the circuit to optimize battery when deployed in the field

References

- All images (not owned by author) are "Public Domain License" – (free for use)
- For more information on accessing AWS from a microcontroller see:
  - https://github.com/ExploreEmbedded/Hornbill-Examples/tree/master/arduino-esp32/AWS_IOT
- Arduino IDE: https://www.arduino.cc/en/software
- Voltage Difference Between Tree and Soil Proof of Concept:
  - "Love CJ, Zhang S, Mershin A. Source of sustained voltage difference between the xylem of a potted Ficus benjamina tree and its soil. PLoS One. 2008 Aug 13;3(8):e2963. doi: 10.1371/journal.pone.0002963. PMID: 18698415; PMCID: PMC2493036."