Performance Analysis of Off-Grid Micro WECS in Harsh Environments

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Outline

- **Background**
- **Problem statement and objectives**
- **Data collection**
- **Statistical analysis**
- **Results and discussion**
- **Further research**

Background

- **Bell-Aliant operates extensive hill-top microwave relay stations throughout Labrador**
- **Originally powered solely by diesel generators with battery bank**
- **Solar power introduced at sites in early 1990's**
- **Wind power installation began in 2003**

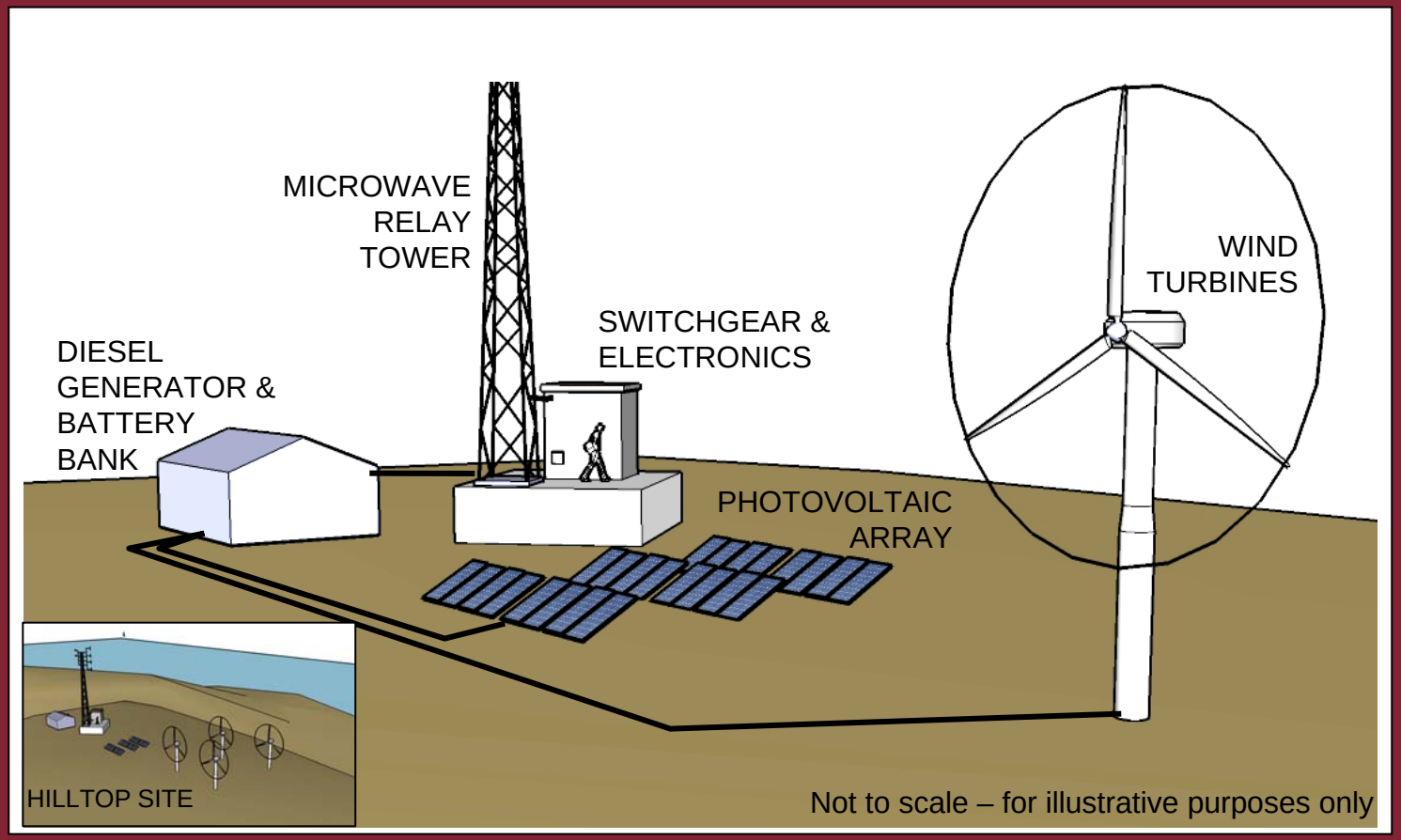
Background

- **Now implementing wind power at off-grid sites**
  - Motivated by high cost and environmental risk of traditional diesel
  - Prospect of improving battery life over photovoltaics by reducing deep cycling
  - Availability and decreased cost of micro WECS

Current Status

- **Six sites**
  - 37 turbines total
- **Sites selected for optimal microwave transmission**
  - not wind power or solar
- **Whisper 100 turbines**
  - 900 Watt
    7ft diameter
    3 blades
- **261 days of production data used in study**

General Site Layout



Problem Statement

1. **There have been mechanical and structural failures at existing WECS sites leading to costly maintenance**
2. **Bell-Aliant would like to improve their basis for evaluating future sites of WECS program**

Problem Statement

Objectives of Study

- **For future sites**
  - Improve power production
  - Increase longevity of turbines
  - Reduce maintenance requirements
- **Give Bell-Aliant rational basis for continuing WECS Program**
- **Give direction for new research**
  - useful for industry

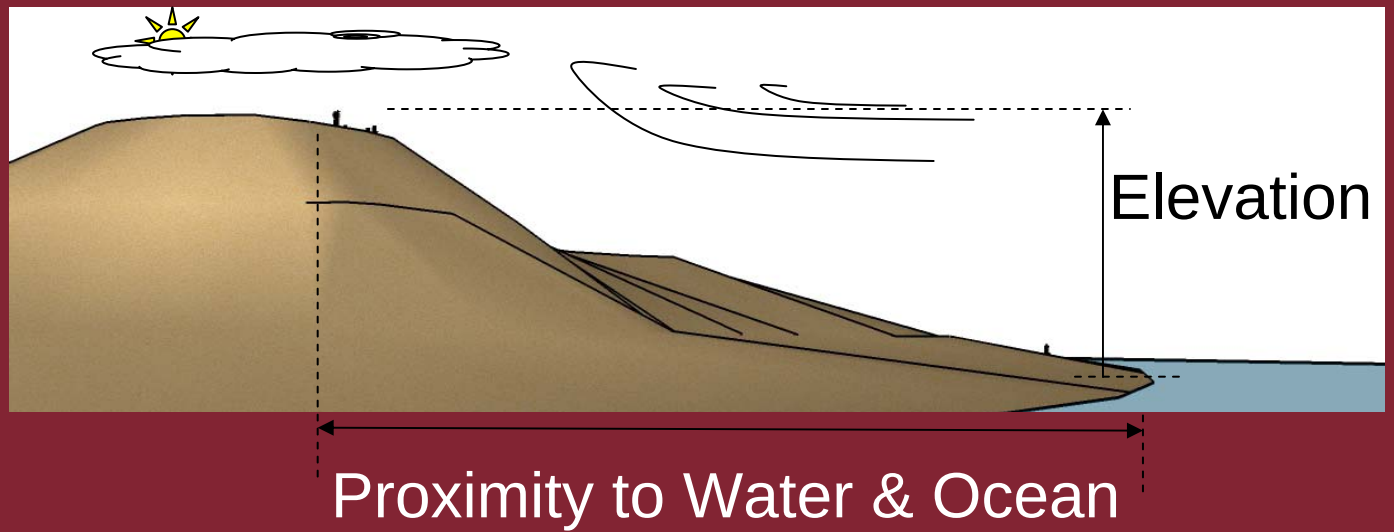
Data Collection & Simplification

- **Identifying machine failure as dependant variable (with failure defined as production stoppage over several days)**
- **The following are potential control parameters**

- **Data assembled**
  - Power Output
  - Geographical
  - Meteorological
  - Maintenance History
  - Bell-Aliant Operational History
- **Simplification**
  - Average number of failures per turbine per site
  - Extremes of regional weather data

Site Characteristics Analyzed

- **Regional Weather**
  - Maximum Gust Speed
  - Minimum Daily Temperature
  - Maximum Daily Precipitation
- **Latitude**



Parameter Details

- **Failure Rate:** ***average failures/turbine/site***
- **Latitude:** ***decimal number***
- **Elevation:** ***meters***
- **Distance to Water:** ***factor from 0 to 10***
- **Distance to Ocean:** ***km***
- **Regional Max Gust Speed:** ***km/hr***
- **Regional Max Precipitation:** ***mm/day***
- **Regional Min Temperature:** ***Kelvin***

✓ ***Minitab 14 used for statistical analysis***

Parameter Correlation with Micro WECS Failure

- **Latitude:** **+0.663 (p=.151)**
- **Elevation:** **-0.005 (p=.992)**
- **Distance to Water:** **-0.286 (p=.582)**
- **Distance to Ocean:** **-0.491 (p=.323)**
- **Regional Max Gust Speed:** **+0.789 (p=.062)**
- **Regional Max Precipitation:** **+0.330 (p=.552)**
- **Regional Min Temperature:** **-0.215 (p=.682)**

- **Nothing statistically significant!**

Results of Analysis

- **Standardized Regression Equation**

Failure Rate =

+ 2.44 * Latitude
+ 1.61 * Distance to Water
- 0.267 * Minimum Regional Temperature
+ 0.171 * Elevation
- 0.125

Coefficient magnitude proportional to level of influence

What This Tells Us

- **Failure rate increases with**
  - Higher latitudes
  - Greater distance from water sources
  - Lower regional temperatures
  - Higher altitudes

- **Caution!**
  - Model limited in predictive ability
  - Doesn’t tell us why

The Next Step

- **Similar Analysis with more data resulting in broader reaching models**
  - More sites with Bell-Aliant
  - Varying geographical locations
  - Varying wind turbine types

- **Forensic analysis of failed units**
  - Why and how failure occurred

Goals of Current Research Program

- **Develop guidelines/protocols for micro WECS application in harsh environments**

- **Technical innovations through research and development for micro WECS in harsh environments**

Thank You

- **Dr. Steve Bruneau**
- **Bell-Aliant**
  - Gervaise White, Jeff Card, Ian Duffett & Steve Corbett
- **CanWEA Conference Organizers**

Questions?

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