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Governor

DEVELOPMENT OF A COST-EFFECTIVE SYSTEM TO MONITOR WIND TURBINES FOR BIRD AND BAT COLLISIONS

PHASE I: SENSOR SYSTEM FEASIBILITY STUDY

PIER FINAL PROJECT REPORT

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Development of a Cost-Effective System to Monitor Wind Turbines for Bird and Bat Collisions – Phase I: Sensor System Feasibility Study is the final report for the Development of a Cost-Effective System to Monitor Wind Turbines for Bird and Bat Collisions project (contract number 500-01-032) conducted by EDM International, Inc. The information from this project contributes to PIER's Energy-Related Environmental Research Program.

For more information on the PIER Program, please visit the Energy Commission's website www.energy.ca.gov/pier or contract the Energy Commission at (916) 654-5164.

Table of Contents

List of Figures

List of Tables

Abstract

Bird and bat collisions with wind turbines are of increasing concern to utilities, regulatory agencies, and environmental organizations. Kills have been documented at several wind farms; however, the magnitude of the problem industry-wide is unknown. This report presents the results of a feasibility study for a sensor aimed at developing an automated tool to monitor collisions with wind turbines.

Accelerometers and fiber-optic sensors were identified as possible contact sensor options. Acoustic emission sensors (microphones) were identified as a non-contact option that need not be installed directly on the rotor blades. The three sensor technologies were evaluated on the basis of installation requirements, signal processing needs, and system cost.

Microphones were deemed the most viable sensor system overall. Accelerometers were ranked second because they need to be installed on the rotor blades and thus require associated hardware mounted on the rotor shaft. Fiber-optic sensors were deemed the least feasible, as they have similar installation requirements as the accelerometers and higher equipment costs; moreover, the fiber-optic systems are bulky and would require custom hardware to reduce their size for practical installation on the rotor shaft.

Keywords: Wind turbine, bird collision, bat collision, collision monitor, collision sensors, bird sensors, Bird Strike Indicator

Executive Summary

Introduction

Bird and bat collisions with wind turbines are of increasing concern to utilities, regulatory agencies, and environmental organizations. Kills have been documented at several wind farms; however, the magnitude of the problem throughout the industry is unknown, in large part because there is currently no cost-effective means for monitoring collisions with turbine blades on a regular and widespread basis. An automated collision monitor is needed to provide the basis for meaningful study. Such a monitor would collect the information necessary to better define the collision problem and help assess the effectiveness of potential solutions.

Purpose

This study is the initial phase of a three-phase effort to develop an automated bird/bat collision monitor that is reliable, affordable, and does not significantly impair wind turbine performance.

Project Objectives

This initial phase investigated the feasibility of developing sensor systems for two distinct wind turbine collision-monitoring applications:

- Technologies suitable for retrofitting common configurations of existing wind turbines.
- Technologies suitable for incorporation in new turbines.

The goal was to identify relatively low-cost sensor systems that can provide long-term, reliable collision monitoring without significant impact on turbine operation. Both contact and non-contact sensor systems were investigated.

Project Outcomes

A literature search identified three candidate sensor technologies for monitoring bird and bat collisions with wind turbines. Accelerometers and fiber-optic sensors were identified as possible contact sensors, i.e., sensors that must be installed directly on the wind turbine rotor blades. Acoustic sensors (microphones) were identified as a potential non-contact sensor that would not need to be installed on the rotor blades. The three sensor technologies were evaluated on the basis of installation requirements, signal processing needs, and system cost. Installation requirements for both existing and new wind turbines were considered.

Conclusions

The findings of the sensor system feasibility study are as follows:

- The acoustic emission sensor (microphone) is expected to be the most viable sensor system overall due to its ease of installation and low-cost, off-the-shelf components.
- Accelerometers are ranked second, primarily because they must be installed on the rotor blades and require associated hardware to be mounted on the rotating rotor shaft. Only a small, lightweight accelerometer would need to be installed on each of the blades and could be installed on the inside of the hollow blades. The accelerometer-based Bird Strike Indicator (BSI) sensor could be modified for this application, thereby minimizing development requirements.

- Fiber-optic sensors are the least feasible, since they have the same on-blade installation requirements as the accelerometers but use more expensive equipment. These sensors are relatively new and their associated hardware is still somewhat bulky and expensive. Custom hardware would need to be developed to make a fiber-optic system practical for installation on the rotor shaft.
- Turbine operating and environmental noise (mechanical sounds, wind, rain, thunder) will be a key factor determining the success of the acoustic emission sensor for collision detection. Rotor blade vibrations will also affect the ability of accelerometers to detect collisions. Field measurements are needed to further evaluate the feasibility of using acoustic sensors versus accelerometers for detecting bird/bat collisions with wind turbines.

Recommendations

Further development of a sensor system to monitor wind turbines for bird and bat collisions should be carried out in two phases. Phase II of this project is envisioned as a proof-of-concept phase to collect data on a test turbine at the National Renewable Energy Laboratory in Golden, Colorado. Phase II will comprise the following steps:

- Assemble off-the-shelf components and develop an acoustic emission sensor system.
- Adapt the BSI for use as a possible accelerometer-based sensor system.
- Test the systems on wind turbines with simulated strikes.
- Determine the sensitivity of the acoustic sensor system versus the accelerometer system.
- Make recommendations for prototype system development.

Phase III of the project should design and assemble a prototype sensor system for field testing and evaluation on different types of operational wind turbines. A commercialization plan should also be developed as part of Phase III.

Benefits to California

This project offers numerous benefits and meets the following PIER program objectives:

- **Developing cost-effective approaches to evaluating and resolving environmental effects of energy production.** An automated sensor system will enable cost-effective study of bird/bat interactions with wind turbines. Such a system will greatly advance scientific understanding of the bird/bat collision problem and allow researchers to assess the efficacy of available tools and methodologies to mitigate the problem.
- **Providing environmentally sound energy.** Identifying effective methods to mitigate wind turbine impacts on wildlife will promote deployment of wind power, a clean energy source.