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Applied Science

Renew Technical Report

Version 1.0

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Renew Technical Report – Version 1.0

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INTRODUCTION

Renew, a Western EcoSystems Technology, Inc. (WEST), proprietary database, is the authoritative source for information on observed bird and bat fatalities and estimated fatality rates at wind energy facilities in North America. As of September 2025, Renew contains reported data from over 800 public and industry-contributed post-construction monitoring (PCM) studies from wind energy facilities across the US and Canada dating back to 1998 (Table 1). These include studies conducted over the last three decades at nearly 400 wind facilities (Figure 1). Renew also houses over 60 PCM studies from solar energy facilities in the US and Canada. This document serves to provide an overview of the Renew database, including its purpose, an overview of PCM, what data it contains, and examples of how the data may be used.

Table 1. Number of public and industry-contributed post-construction monitoring studies in Renew.

Industry	United States	Canada	Total
Wind	720	165	885
Solar	6	58	64

Background

Renew was first established in 2009 with the goal of summarizing the growing body of research available in PCM reports to offer unique insights into the impacts on wildlife, particularly birds and bats, from wind and solar energy facilities. Today, Renew is the largest collection of publicly available and industry-contributed PCM studies and continues to grow by an average of 50–100 new studies per year. Renew includes data presented in PCM reports available online or provided by state and federal agencies, as well as those contributed by developers in the renewable energy industry, which may not otherwise be available for use. Data available within Renew includes fatality rates, carcass counts, details of PCM study design, and characteristics of the energy facility, such as turbine specifications and land cover.

As more renewable energy facilities are being developed in North America, more PCM studies are completed, and more data can be contributed to Renew on a regular basis. By cataloging observed fatalities and estimated fatality rates across facilities with a wide range of project characteristics, Renew allows users to leverage associations within the data to address a broad range of questions. Renew output is easily accessible by WEST and standardized to efficiently summarize and provide context for observed fatalities and fatality rates relative to other facilities in the region, and can help inform the understanding of relative risk at a new facility before and after it is constructed. The information can accommodate research interests pertaining to fatality patterns, which, in the past, have been used to inform monitoring guidelines set forth by the US Fish and Wildlife Service (USFWS).

Geographic Representation

There are nearly 155 gigawatts of installed wind generation capacity in the US, and 18 gigawatts of wind generation in Canada (American Clean Power [ACP] 2025, Canada Renewable Energy Association 2025). Data contained in Renew consists of PCM survey results across 37 states and territories in the US and five provinces in Canada (Figure 1). Renew includes data from more than 20% of the total installed turbine megawatt (MW) capacity in the US.

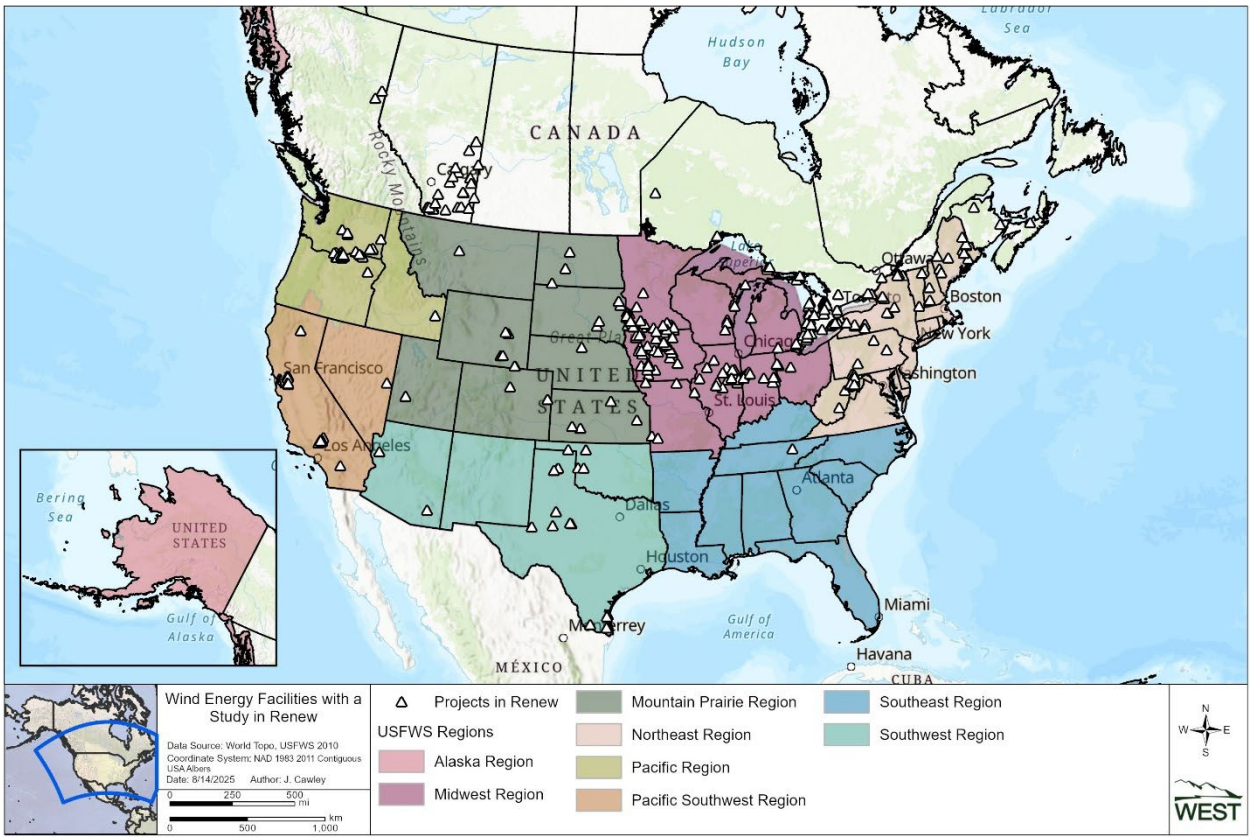

Figure 1. Map of wind facilities in the US and Canada with at least one public or owner-permission post-construction monitoring study in Renew.

POST-CONSTRUCTION MONITORING OVERVIEW

Why is Post-construction Monitoring Conducted?

The USFWS recommends at least one to two years of PCM for all wind energy facilities in the US (USFWS 2012). In Canada, most provincial wildlife agencies require a minimum of two or three years of PCM (Government of Ontario 2011, Government of Alberta 2017). One of the primary goals of these guidelines is to determine how the fatality rates at a facility compare to the fatality rates from other facilities in similar landscapes and to evaluate if additional monitoring or fatality minimization (e.g., curtailment,[1] deterrents) is warranted. Beyond demonstrating adherence to agency guidelines or regulations, PCM studies may also be conducted to comply with permits or to confirm the efficacy of a particular minimization strategy. While the US and Canada have different regulatory landscapes, Renew is uniquely positioned to assist with providing context on the relative fatality risk of facilities in both countries.

How is Post-construction Monitoring Conducted?

Most modern PCM studies consist of two main components: a trained observer systematically searching designated areas around wind or solar energy infrastructure (e.g., turbines or

[1] Curtailment is the act of feathering the turbine blades (angling them parallel to the wind) to slow or stop them from turning.

solar arrays) for carcasses, and bias trials used to estimate the probability that an observer detects a carcass. Bias trials are designed to adjust for the fact that even experienced searchers will not find every bird or bat carcass during the monitoring period, and to account for changes in detection through time and between different types of search methods. Bias trials are used to estimate:

- How effectively searchers detect carcasses (**searcher efficiency**)
- The rates at which carcasses remain available to be found (**carcass persistence**)
- The proportion of carcasses that fall in the searched areas (**search area adjustment**)

These factors are combined to adjust the raw counts of carcasses for detection bias and to calculate an estimated fatality rate (individuals per MW or per turbine), along with a measure of confidence in that estimate.

Federal- or state-issued permits, such as incidental take permits (ITPs) or eagle take permits (ETPs), often require PCM studies to be designed such that they meet a certain target for the site-wide detection probability (*g*) using the Evidence of Absence estimator. By cataloging bias-adjustment estimates and fatality rates from existing PCM studies, Renew can be used to meet these objectives. For example, understanding observed carcass persistence rates from representative facilities in the region can be valuable in ensuring the target *g* is met. Carcass persistence data for a given carcass size can be queried in Renew from facilities in a similar region and with similar habitat types. Additionally, Renew can provide search-area adjustments from projects with turbine characteristics that are similar to the project of interest.

DATA MANAGEMENT

The proper management of data in Renew is critical in ensuring its accuracy, relevance, and timeliness. The data-management process involves systematically reviewing and updating the database to reflect the most current information. WEST's data management plan for Renew includes data storage, security, and quality.

Data Storage

Renew is stored securely in a Microsoft SQL Server (Microsoft 2022) relational database with georeferenced location information. Renew has a comprehensive collection of reported information related to fatalities, fatality estimates, study design characteristics, and more. See Appendix A for a full list of data fields stored in Renew.

Database Security, Information Security Compliance

WEST is certified under the International Organization for Standardization (ISO) 27001 and ISO 27002 standards, which are internationally recognized frameworks for information security management. These certifications demonstrate WEST's commitment to safeguarding data through a systematic approach to managing information security risks, which includes policies, procedures, protocols, and technical controls. These items are woven through WEST's data management processes to ensure high-quality and secure data.

The raw data and source reports in Renew are not shared with outside parties. There is no third-party or public access to the database; only WEST has direct access to Renew.

Quality Assurance and Quality Control

Quality Assurance and Quality Control (QA/QC) are integral components of the Renew data management process. All data entered into Renew undergo a rigorous, multi-step QA/QC

process by trained data-entry technicians to ensure accuracy, reliability, and standardization. This comprehensive process ensures the data in Renew is of the highest quality, providing reliable and accurate information for analysis and decision-making.

Most available PCM reports can be entered into Renew. However, at WEST's discretion, reports may be excluded from Renew if it is determined to not meet data quality standards.

Permission Levels

Renew data is stored under three unique permissions levels that dictate how the data is summarized and referenced, as defined below.

"Public" data have been published online, for example, in the form of a monitoring report to the USFWS or state wildlife agency, journal article, or public summary of the data (e.g., data published in another document like a Habitat Conservation Plan [HCP], a report provided by a federal or state agency). Data contained in "public" reports may be explicitly attributed to the facility or study, but only in limited circumstances. Facility names are not included in data visualizations generated from Renew but may be included in report text, for example, to describe fatality rates or species found at nearby facilities.

"Owner-permission" data have permissions tied to explicit owners of the report that have granted permission for the data to be used in Renew. When owners agree, the summaries from these reports are only included in combination with information from other facilities. Data contained in "owner-permission" reports will not be explicitly attributed to the owner, facility, or study but instead will be aggregated across studies (e.g., "20 hoary bats were found across six wind facilities in 2015"). Facility names will not be listed within figures, to ensure anonymity. Data with "owner-permission" will only be provided to collaborators outside of WEST with anonymized facility information.

Renew analyses with "public" or "owner-permission" data will typically not include the report citation in the appendix of the document, with some exceptions (e.g., peer-reviewed journal articles, HCPs). Facility information from publicly available sources, such as the US Wind Turbine Database (US Geological Survey et al. 2025), may be used in data summaries and analyses even if that information is not available within the report itself.

"Confidential" data have restricted permissions and are not included in Renew summaries. This is the assumed permissions level for all reports, until the report is publicly available or permission has been obtained.

To contribute PCM reports to the Renew database, please contact the Renew team at RenewSupport@west-inc.com. WEST permission levels can be applied to meet data privacy concerns while contributing to research on wind or solar wildlife interactions.

EXAMPLE USES OF RENEW

Fatality Comparisons

WEST uses a set of standardized outputs that can be used to summarize fatality data on a variety of spatial and temporal scales. These summaries (fatality comparison figures and multi-scale fatality summaries) can be used as a supplement in a Bird and Bat Conservation Strategy, standard PCM report, or HCP, providing valuable context on site-specific impacts relative to the facility of interest.

Fatality Comparison Figures

To answer the questions outlined in the *Land-Based Wind Energy Guidelines* (USFWS 2012) for Tier 4 studies, fatality comparison figures are standardized figures routinely created to provide a representative sample of fatality rates from other facilities in a similar region that can be compared with the fatality rates calculated

during the Tier 4 study (Figure 2). WEST imposes inclusion criteria to identify estimates from Renew that are sufficiently comparable to be included in the comparison figures. Inclusion criteria can be further refined to provide the most relevant comparisons depending on the characteristics of the study.

For example, when presenting a fatality comparison figure for a study that implemented curtailment, the estimates from Renew can be restricted to studies that also included curtailment. The following inclusion criteria apply to estimates included in the standard fatality comparison figures.

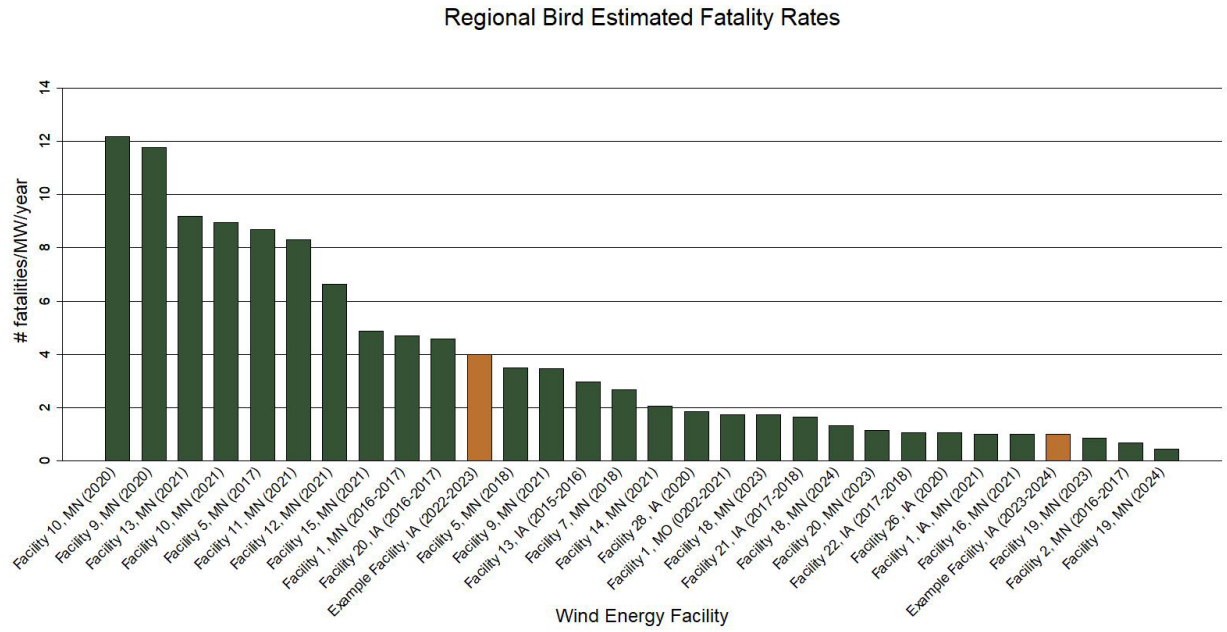

Figure 1. Example Fatality Comparison Figure summarizing bird fatality rates for a facility of interest (orange bars for two years of monitoring) to comparable wind energy facilities in the region (green bars).

Note: This figure is typically provided as part of a post-construction monitoring report. The standard Renew Fatality Comparison Figure can also be produced to show regional bat and diurnal raptor fatality estimates.

Timing criteria: Fatality estimates are restricted to studies that surveyed at least during the time periods known to contain most bird fatalities (April 15 to October 15) and bat fatalities (July 15 to October 15).

Search frequency criteria: For bat fatality estimates, searches must occur at least every two weeks during the peak risk periods as defined above. For bird fatality estimates, including raptors, searches must occur at least once per month.

Estimate criteria: Estimates from Renew are selected such that 30 of the most representative fatality rates are used in comparison figures. If more than 30 estimates meet all required criteria, estimates calculated using modern estimators such as GenEst (Dalthorp et al. 2018, Simonis et al 2018) and Huso (Huso et al. 2017) are prioritized over older, less robust estimators such as the Shoenfeld (2004), Jain (2005), and Erickson (2006) estimators. Estimates must also include adjustments for sources of bias (i.e., search efficiency, carcass persistence, and area searched). Most estimates in Renew were calculated using the GenEst, Huso, or Shoenfeld estimators.

Operational restrictions: Estimates are required to be from normally operating turbines, that is, those that were not curtailed. Over the last decade, approximately 39% of public PCM studies in Renew were from facilities that curtailed their turbines at night for bats.

Multi-scale Fatality Summaries

Multi-scale fatality summaries provide a description of seasonal patterns in fatalities that may occur in a region (Table 2, Figure 3). When viewed across multiple spatial scales (including the state, bird conservation region, ecoregion, USFWS region, and country), seasonal patterns in the timing of fatalities can help indicate when some species or species groups may occur more often as fatalities and, therefore, when minimization measures may be most effective. These outputs also include summary statistics on fatality rates for bats, raptors (a subset of all birds), and all birds (including raptors) across each spatial scale, which provide context on the range of fatality rates observed for wind facilities in the region.

Table 2. Example multi-scale fatality summary of summary statistics on fatality rates for bats across several spatial scales from the state to the entire US. Summaries can also be generated for all birds and raptors.

	Fatality estimates (birds/megawatt/year)					
Spatial Scale	**Minimum**	**Maximum**	**Median**	**Mean**	**Facilities**	**Studies[1]**
South Dakota	1.69	1.69	1.69	1.69	1	3
Badlands and Prairies BCR	0.59	1.49	1.04	1.04	2	4
USFWS Mountain-Prairie Region	0.56	5.95	1.49	2.32	9	15
Great Plains	0.08	8.44	2.96	3.19	37	48
US	0	8.45	2.63	2.87	83	125

[1.] Multiple studies may occur at a given facility in different years.

BCR = Bird Conservation Region; USFWS = US Fish and Wildlife Service.

Habitat Conservation Plan Take Predictions

Energy facilities in pursuit of a federal or state-level ITP often must develop a prediction of the expected fatality of the sensitive species for which they are seeking coverage. Take predictions can be developed using multiple different approaches, but a key component in most methods is to use data from nearby facilities with similar landscapes and seasonal risk patterns. With records of sensitive-species occurrence and reported fatality rates from Renew, a “species-composition” approach can often be used with data from comparable facilities to develop a take prediction. This results in a species-specific estimate of take that is fundamentally a product of a species proportion (ratio of sensitive to species to all birds or bats found during the study) and an average fatality estimate. Renew also includes species-specific estimates calculated using Evidence of Absence, which provide valuable context on observed fatality rates for sensitive species at nearby facilities operating under an ITP or ETP.

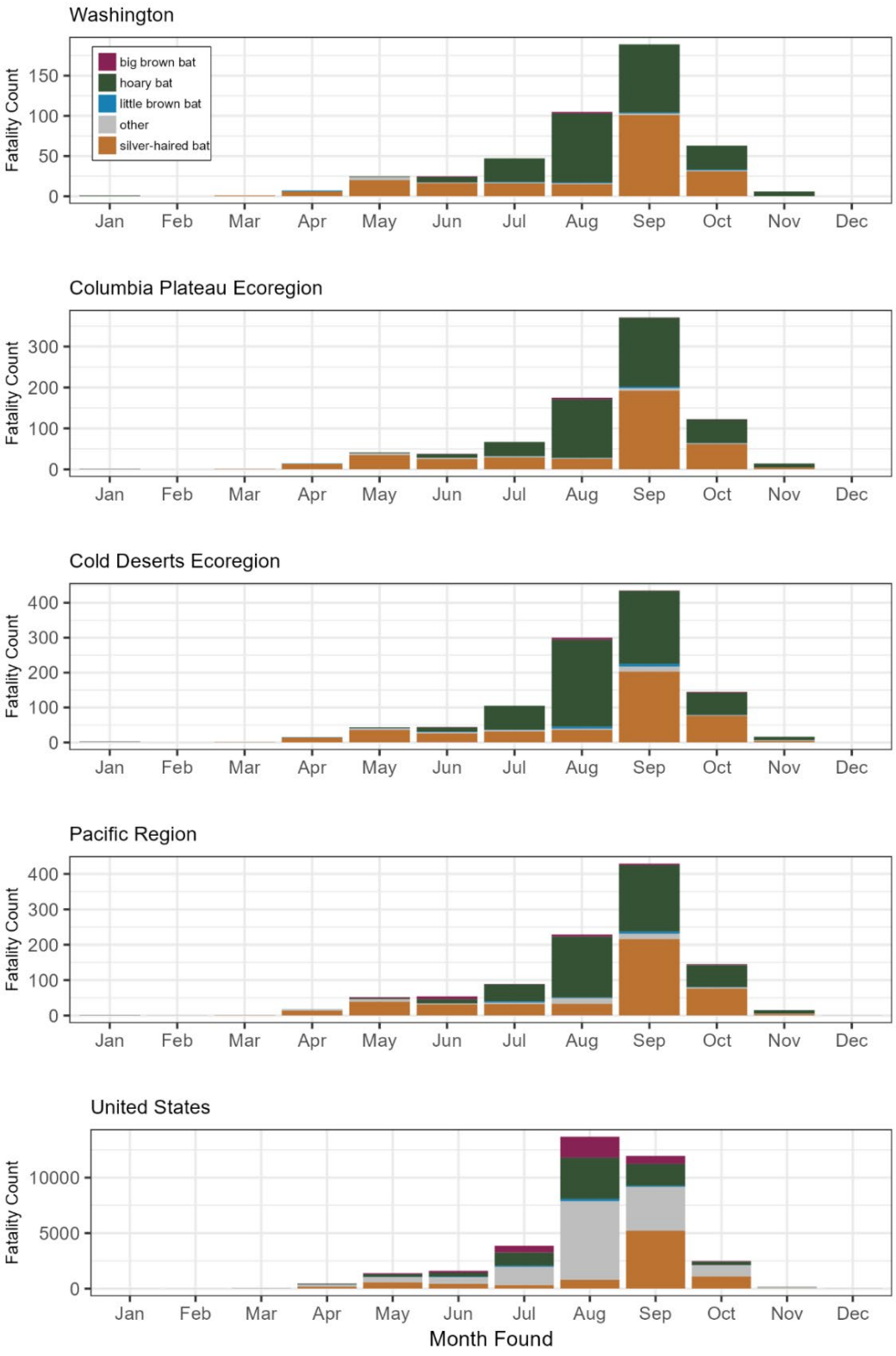

Figure 3. Example multi-scale fatality summary of fatality timing for bats across several spatial scales from Washington state to the entire US. Summaries can also be generated for all birds and raptors.

Publications and Technical Reports

Renew data can be used to answer questions about the impact of renewable energy infrastructure on wildlife populations. Below are a sample of peer-reviewed publications and technical reports that WEST has authored using data from Renew.

Bat Fatality timing at Wind Farms Across the Continental U.S. and Ontario, Canada: An Investigation of When Bat Fatalities Occur Throughout the Year

Electric Power Research Institute (EPRI), 2020

EPRI (2020a) examined spatial patterns in the timing of bat fatalities. The analysis revealed an overlap between peak fatalities of hoary bats (*Lasiurus cinereus*) and eastern red bats (*L. borealis*) in fall and a later fatality peak for silver-haired bats (*Lasionycteris noctivagans)*. At wind facilities that have multiple years of studies, the timing of peak fatalities was similar across years. Lastly, the peak of hoary bats fatalities in the fall was correlated with longitude: the further west the wind facility was located, the later in fall peak fatalities occurred. In the context of operational curtailment, these findings suggest temporal curtailment regimes may not provide uniform benefits across species.

Relationship Between Bat Fatality Rates and Turbine Size at Wind Farms Across the Continental U.S. and Southern Canada: An Investigation Into the Occurrence of Bat Fatalities in Relation to Turbine Size

EPRI, 2020

EPRI (2020b) examined relationships between turbine characteristics and bat fatalities. The authors evaluated the effect of hub height, blade length, and turbine MW capacity on bat fatality rates. Weak correlations were found between bat fatality rates and turbine size characteristics, with bat fatalities peaking at intermediate turbine sizes and decreasing as turbine sizes increased further. The authors concluded more research is needed to fully understand how turbine size impacts bat fatalities.

Predicting Eagle Fatalities at Wind Facilities

Bay, K., K. Nasman, W. Erickson, K. Taylor, and K. Kosciuch, 2016

Journal of Wildlife Management

Bay et al. (2016) generated an estimate of golden eagle (*Aquila chrysaetos*) collision rates at wind energy facilities across the US for use in the USFWS modeling framework for predicting golden eagle fatality rates. Using more recent data and a larger data set, the authors found updated collision rates were approximately 50% less than the previous estimates used by the USFWS.

A Comprehensive Analysis of Small Passerine Fatalities from Collisions with Turbines at Wind Energy Facilities

Erickson, W. P, M. M. Wolfe, K. J. Bay, D. H. Johnson, and J. L. Gehring, 2014

PLoS ONE

Erickson et al. (2014) estimated fatality rates of small passerines at wind energy facilities across the US and Canada. Passerines are the most common type of bird observed during PCM. The authors found fatalities peaked in spring and fall and fatality rates from turbine collisions were much smaller than fatality rates from collisions with communication towers, which supports other evidence that the impact of wind turbines to passerines is small relative to other sources of fatality.

Unpublished Examples of Research

Renew informs many unpublished reports, technical memoranda, and conference presentations that have addressed topics such as the siting of renewable energy infrastructure, bat population trends, and alternative PCM approaches. Below are a few examples.

Improving Monitoring for Endangered Bat Species based on Twenty-six Years of Data and Over 600 Carcass Studies at Wind Energy Projects

Good, R., Q. Hayden, F. Kulzer, J. Lloyd, S. Howlin, V. Zero, A. Hale, P. Rabie, C. Read, S. Yanuzzi. 2025

WEST leveraged Renew to help ACP and the USFWS to inform the USFWS' new approach to measuring bat fatalities at wind energy facilities that receive ITPs or technical assistance letters. The aim of the new framework was to continue focusing traditional monitoring efforts on places where risk or uncertainty about risk was high but to use the new framework to reduce monitoring requirements in well-studied areas where risk to bats is relatively low.

What Can We Learn about Bat Risk at Wind Energy Facilities by Examining Turbine Specifications and Public Fatality Data?

Bishop-Boros, L., A. Hale, R. Good, F. Kulzer and S. Howlin, 2025

This study used Renew data to investigate the relationship between turbine ground clearance and bat fatalities as a follow up to EPRI (2020b). The authors used a species-composition approach to compare estimated fatality rates of little brown bats (*Myotis lucifugus*), Mexican free-tailed bats (*Tadarida brasiliensis*), and tricolored bats (*Perimyotis subflavus*) to turbine ground clearance from facilities throughout the US.

Trends in Tree Bat Abundance Using Post-construction Monitoring Fatality Rates as a Proxy

Kulzer, F., J. Lloyd, E. Baumgartner, V. Zero, and A. Hale, 2024

To gain insights into population trends of four bat species commonly found as fatalities at wind turbines, the authors examined trends in fatality rates as a proxy for population size under the assumption that the probability of a bat colliding with a turbine has remained constant over time, and, thus, temporal trends in fatality rates could serve as an approximation of temporal trends in abundance.

Improving Definitions of Tricolored Bat Habitat will Facilitate Siting/Permitting throughout the Species' Range

Bishop-Boros, L., M. True, P. O'Brien, and K. Hammond-Rendon, 2017

In 2024, the tricolored bat was proposed to be listed as endangered due to severe population decline. Using Renew data, the authors characterized suitable habitat for this species, information that will help developers of wind energy facilities avoid and minimize impacts through proper siting of wind energy facilities in the tricolored bat range.

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Appendix A. Data Reference Guide

Appendix A. Data reference guide containing a description of key data contained within Renew. Note that field names are generalized for readability and differ from the actual database schema.

Data	Description
FACILITY-LEVEL INFORMATION	
Client Name	Name that identifies the owner of the facility at the time of the study
Facility Name	Energy facility name
Country	Country where the facility is located
State/Province	State(s) or province(s) where the facility is located
County	County where the facility is located
Facility Location	Coordinates of facility's geographical center point
USFWS Region	US Fish and Wildlife Service region where the facility is located
Ecoregion Level I[1]	USEPA Ecoregion Level I of the facility
Ecoregion Level II[1]	USEPA Ecoregion Level II of the facility
Bird Conservation Region[2]	Name of Bird Conservation Region
Facility Total MW	Total megawatt capacity of facility
Total Turbine Count	Total number of turbines at the facility, if energy type is wind
Per Turbine MW[3]	Nameplate megawatt capacity for wind turbines
Energy Type	Indicator for type of energy facility (wind or solar)
Facility Habitat	Habitat type(s) in facility boundary
TURBINE-LEVEL INFORMATION[3]	
Turbine Manufacturer	Company that manufactured the turbine
Model Name	Turbine model name
Rotor Diameter	Diameter of the circle swept by rotating blades
Hub Height	Distance from the ground to the middle of the turbine rotor
Blade Length	Distance of turbine blade from the center of the rotor to the end of the blade
Base Radius	Radius of turbine tower at the base
Total Height	Distance measured from the ground to the tip of the rotor blade when extended vertically to its highest point
Manufacturer's Cut-in Speed	Minimum wind speed the turbine starts generating electricity
Megawatt	Maximum amount of electricity that the turbine can generate under optimal conditions
STUDY-LEVEL INFORMATION	
Is Incidental Take Study	Logical indicator: true if the study was conducted under an Incidental Take Permit
Permission Level	Whether the report is considered "Public," "Owner-Permission," or "Confidential"
Study Date Range	Date range of the study
Sampled Turbine Count[3]	Number of turbines surveyed
Report Reference	Report title, author, and year
Public URL	URL of location report was accessed (if public)
Accessed Date	Date report was accessed (if public)
Turbine Operational Curtailment[3]	Logical indicator: true if the study utilized operational curtailment of turbines
FATALITY INFORMATION	
Is Censored	Logical indicator: true if a fatality was censored and not included in a Huso fatality estimate
Species	Species common name and scientific name
Size Class	Size class used for analysis (e.g., bat, small bird, or large bird)
Age Class	Fatality age or life stage
Sex Class	Fatality sex
Date-Time Found	Date and time the fatality was found

Appendix A. Data reference guide containing a description of key data contained within Renew. Note that field names are generalized for readability and differ from the actual database schema.

Data	Description
Season	Season the fatality was found
Turbine Name[3]	Turbine name where the fatality was found (e.g., T19)
Construction Phase	Construction phase(s) included as part of the study, if applicable
Incidental Find	Logical indicator: true if a fatality was found outside of a fatality search
Physical Condition	Physical condition of fatality
Estimated Time of Death	Estimated time of death of fatality in days
Outside Plot	Logical indicator: true if a fatality was found outside of the search area
Bearing From Turbine[3]	Bearing (degrees) from turbine to fatality location
Distance From Turbine[3]	Distance (meters) from turbine to fatality location
Habitat of Fatality	Type of habitat the fatality was found in
Percent Vegetation Cover	Percent of ground covered in vegetation in the 1 x 1 meter square around the fatality
Visibility Index	Relative visibility of the location of the fatality (e.g., easy, moderate, difficult)
Aided Search Type	Indicates an aided search type if used (e.g., dog, drone, or off-road vehicle)
Turbine Operation[3]	Indicates the operation of the turbine given the fatality's estimated time of death (e.g., feathering, curtailment, normal)
Cut-in Speed[3]	Cut-in speed of the turbine given the fatality's estimated time of death
ESTIMATE INFORMATION	
Estimator	Estimator used (e.g., GenEst, Huso, Shoenfeld, Evidence of Absence)
Estimate Type	Type of estimate calculated (e.g., adjusted fatalities per turbine, adjusted fatalities per MW, adjusted fatalities per facility, searcher efficiency, area adjustment, probability of persisting through the search interval, probability of detection)
Estimate	Numeric value of estimate
Confidence Interval	Lower and upper bound of the confidence interval of the estimate
Size Class	Size class used for analysis (e.g., bat, small bird, or large bird)
Estimates Sampled Turbine Count[3]	Number of surveyed turbines incorporated into the fatality estimate
Plot Type	Type of plot(s) surveyed for the estimate (e.g., full plot, road and pad, scan, solar array)
Plot Extent	Shape and size of the plot(s) surveyed for the estimate
Search Interval	Average number of days between searches
Turbine Operation[3]	Curtailment regime implemented for turbines included in the estimate
Season(s)	Season(s) included in the estimate
Estimate Year Range	Year range of survey data incorporated into the estimate

1. US Environmental Protection Agency (USEPA). 2025. Ecoregions. Center for Public Health and Environmental Assessment, USEPA, Corvallis, Oregon. Updated March 2025. Accessed May 2025. Available online: https://www.epa.gov/eco-research/ecoregions
2. North American Bird Conservation Initiative. 2025. Bird Conservation Regions Map. Washington, D. C. Accessed May 2025. Available online: https://nabci-us.org/resources/bird-conservation-regions-map/
3. Not applicable to solar data.