NRG White Paper

Exploring How Attenuation Affects NRG Systems' Bat Deterrent System

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Overview

There is no denying that bats are exceptionally unique animals; they are the only mammal that can actively fly, the only land-based animal to echolocate, and they live surprisingly long lives, given their diminutive body size. Bats are also crucial to our environment; they are phenomenal pollinators and provide efficient (and chemical-free) pest control. But some bat species are in rapid decline. White-Nose Syndrome, a disease that causes a white fungus to grow on a bat's nose and wings, disrupting both their hydration and hibernation cycles, has devastated many cave-roosting bat populations in North America. Human encroachment on bat habitat has caused population displacement and decline globally.

The wind industry, while providing a plethora of benefits to our planet, has an unfortunate effect on bats. For reasons still largely unknown, bats collide with wind turbines. As bat conservation has become an increasingly pressing issue for wind farm developers and owners, NRG Systems, Inc. developed a bat deterrent solution for the wind industry, as well as other infrastructure projects. NRG Systems' acoustic Bat Deterrent System (BDS) uses high-frequency sound (ultrasound) to create airspace that is unnavigable to bats.

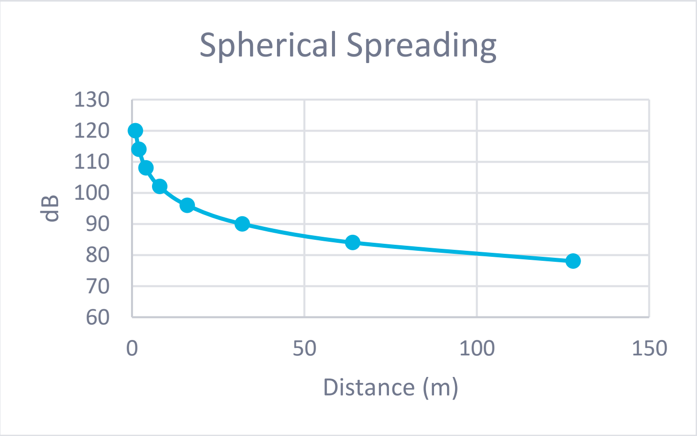
The system relies on many factors to be successful. Some of those factors are controlled by NRG, such as design and manufacturing, but several factors are purely up to nature. For example, certain environmental conditions contribute to the loss of sound over distance – a phenomenon known as attenuation – which can impact the effective range of NRG's BDS.

Understanding Attenuation and Its Effect on Ultrasound

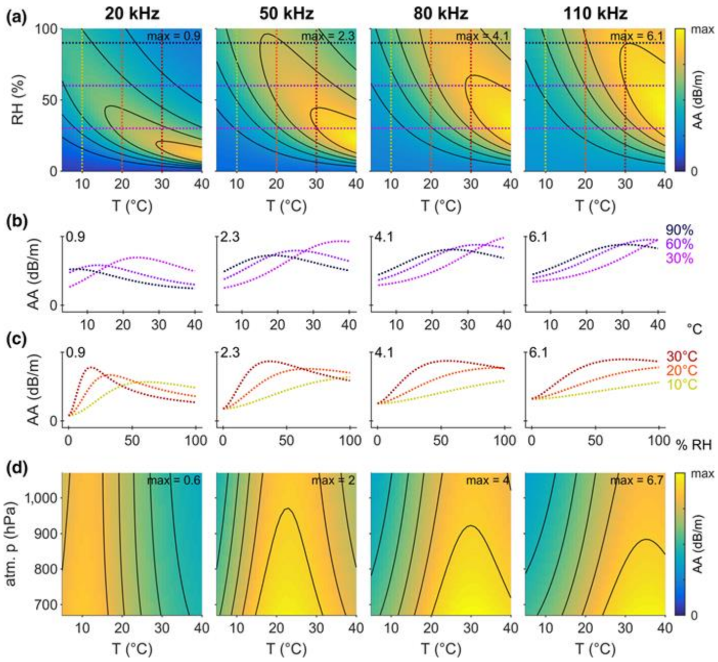
Sound Propagation

To understand attenuation or the loss in sound volume (referred to as Sound Pressure Level and measured in decibels [dB]) over a distance, one must start with sound propagation – the method by which sound waves travel. Propagation is affected by three major factors: spreading, atmospheric attenuation, and surface effects. Since most applications of NRG's BDS place the technology far enough from surfaces to avoid any impact on propagation, we will ignore surface effects for this white paper.

Spreading in sound propagation is observed in two forms: spherical and cylindrical. Spreading can be considered spherical if emanating from a single point (such as NRG's BDS), or cylindrical if it is emanating from a line (such as a freeway). As sound waves spread from a single point-source, the available energy to perceive that sound at a new point in space reduces as a function of distance and area. In air, for every doubling of the distance (*r*), the sound level is reduced by 6 dB. For example, if the source sound measured at 1 meter is 120 dB, it will be 114 dB at 2 meters, and 108 dB at 4 meters. Spreading is independent of frequency, meaning that in the case of NRG's BDS, all frequencies experience a reduction of dB at the same rate.

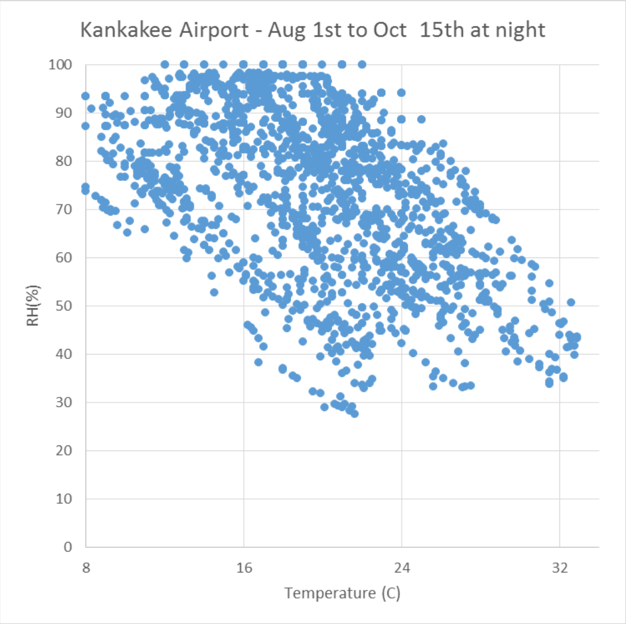


In addition to spreading, attenuation is caused by atmospheric sound losses resulting from temperature, humidity, and air pressure's effect on sound absorption. The attenuation coefficient is a frequency-dependent value that when used in conjunction with the spreading loss described above, allows for the calculation of the sound level at a distance with specific atmospheric conditions. The higher the frequency, the "quicker" absorption causes attenuation, leading a sound to dissipate. But the relationship between temperature and humidity is nonlinear. Cool, dry air offers the best resistance against attenuation, and as the temperature and humidity start to rise, the attenuation coefficient increases as well. The worst conditions for ultrasound appear around 30-40°C and relative humidity (RH) of about 40-50%. As the relative humidity increases though, the attenuation coefficient begins to decrease. This works in favor of most ultrasonic bat deterrents since the technology is often running at night when bats are most active and temperatures are often cooler, and the relative humidity is often very high. The following chart, provided by Wiley, illustrates the concept of attenuation, and the effects of temperature, humidity, and frequency.



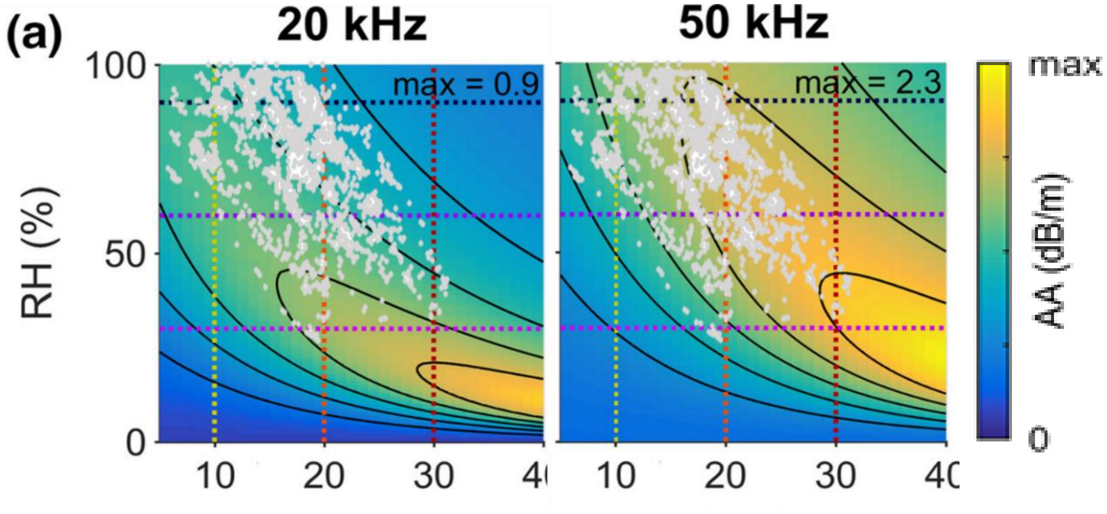
Atmospheric attenuation of sound in air (AA, separately for sound frequencies of 20, 50, 80 and 110 kHz, from left to right) varies with frequency, temperature, relative humidity, and atmospheric pressure. (a) AA (color-coded) as a function of temperature and relative humidity. Note the varying scaling of the color-code for AA, with its maximum value given in the upper right corner of each panel. Black contour lines are drawn at equidistant and constant values of AA. Horizontal and vertical dotted colored lines indicate the cross-sections shown in b and c. Atmospheric pressure was set to 1013.25 hPa. (b) AA as a function of temperature, shown for three relative humidity's (30%, 60%, 90%, see dotted colored lines in a). Note the different scaling of the y-axes matching the color code in a. (c) AA as a function of relative humidity, shown for three temperatures (10, 20, 30°C, see dotted colored lines in a). Note the different scaling of the y-axes matching the color code in a. (d) AA (color-coded) as a function of temperature and atmospheric pressure. Note the varying scaling of the color-code for AA, with its maximum given in the upper right corner of each panel. Black contour lines are drawn at equidistant and constant values of AA. Relative humidity was set to 70%. For comparison, Figure S2 presents the same data with equal scaling of the color-code and y-axes, showing better the differences in AA with frequency instead of with T and RH. (Goerlitz 2018)

Conclusions



Looking at data from a wind project utilizing NRG's Bat Deterrent Systems may provide the best opportunity to understand the concept of attenuation and how it affects ultrasound's ability to deter bats. The accompanying temperature vs. humidity plot is actual meteorological data from an airport near a wind farm, filtered from sunset to sunrise, during a typical bat season of August 1 to October 15. The plot shows that most of the observations were recorded when relative humidity was greater than 50%, and plenty of observations when relative humidity was more than 75%.

Using the available wind project data, we were able to super-impose the temperature-RH points on the attenuation curves for two of the frequencies used by the Bat Deterrent Systems. This shows that while there is a certain and unavoidable effect on sound levels due to absorption caused by temperature and humidity, the cooler air and higher relative humidity characteristic of nighttime, likely provide the best-case scenario for an ultrasonic bat deterrent to maintain desired sound levels. When these conditions are present, attenuation is minimized, meaning the BDS-produced ultrasound is more abundant for longer, creating an airspace that while unpleasant for bats, ultimately keeps them out of harm's way.



For more information about NRG Systems or its Bat Deterrent System, please contact bats@nrgsystems.com.

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