2021Q25 (MICROWAVE PATHS)

Do you know what a microwave is? No, not the appliance used to heat up your food. A microwave is an electromagnetic wave with frequencies ranging from 300 megahertz (MHz) to 300 gigahertz (GHz). These microwaves can be used to transmit information from one place to another by sending a signal from a transmitter to a receiver. This signal can transmit information up to 50 kilometers (km). That's over 30 miles away! This technology is very useful for transmitting information; however, it requires a path free of obstructions to successfully transmit that data. Obstructions are typically avoided by putting the transmitter and receiver on towers. While this avoids low obstacles like trees and houses, taller structures like buildings, cell towers, or wind turbines can be in the way. To avoid interference, those building tall structures can conduct a microwave path study before the structures are built.

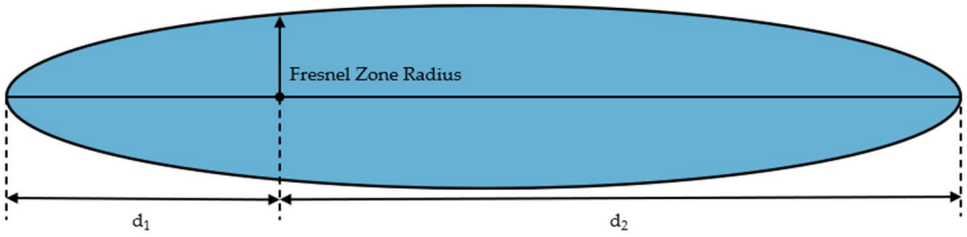
To determine how far a turbine must be placed to avoid interfering with a microwave path, we first have to calculate the wavelength of the microwave. The wavelength of a microwave can be calculated by dividing the velocity of the microwave by the frequency of the microwave. The velocity of all microwaves is the speed of light, which is 300,000,000 m/s.

$$Wavelength\ (m) = Speed\ of\ Light\ (m/s)\ /\ Frequency\ (Hz)$$

A Fresnel Zone is an ellipsoidal region along the microwave path that can be used to determine if a microwave path will be affected by an obstacle. The radius of the Fresnel Zone is dependent on the wavelength (λ) of the microwave in meters, the distance from the transmitter (d_1) in meters, the distance from the receiver (d_2) in meters, and the number of the Fresnel zone (n). The number of the Fresnel Zone is an adjustable variable that increases the radius to ensure that the microwave's path isn't interfered. One Energy sites wind turbines outside of the Second Fresnel Zone (n = 2) following industry standards.

$$Radius = \sqrt{\frac{n\lambda d_1 d_2}{d_1 + d_2}}$$

This is a diagram of a Fresnel Zone that is centered on a microwave path. It forms an ellipsoid that is thinnest at the transmitter and receiver and widest in the middle.



Level 1: A microwave has a frequency of 20 GHz. Calculate the wavelength of the microwave.

Level 2: You are siting a wind turbine that is 10 km from the transmitter and 15 km from the receiver of a microwave path. Using the wavelength calculated in Level 1, calculate the radius of the Second Fresnel Zone to determine how far from the microwave path the turbine must be sited to avoid interfering with the microwave path.