

### READING PASSAGE

You may have noticed that wind turbines are typically installed on very tall towers. Have you ever thought about why these towers have to be so tall? What do you think happens to the wind speed as you go higher and higher off the ground?

It turns out that winds get much stronger as you go higher above the Earth. The main reason for this is known as “ground drag.” Ground drag is the friction that occurs between the surface of the Earth and the moving air molecules (wind) that flow over it. Ground drag reduces the velocity of the wind, thereby reducing the kinetic energy available in that wind. This is particularly important for wind power, since the output of a wind turbine is proportional to the cube of the wind speed. That means that doubling the wind speed can give you eight times the kinetic energy available in the wind!

This difference in wind speed at different elevations above Earth is known as wind shear. Wind shear is a very important concept for wind turbine developers and installers to understand—since a small difference in wind speed can make a huge difference in power output.

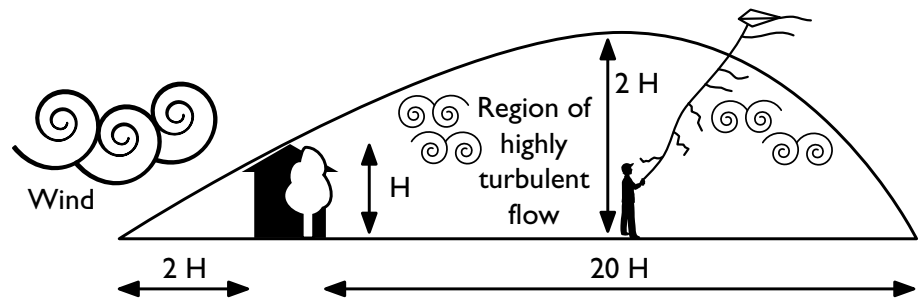
Landscapes with buildings and trees create much more ground drag than open fields or oceans—which is why some of the best wind resources in the United States are in the Great Plains regions and offshore areas like the Atlantic Ocean, the Gulf Coast, and the Great Lakes.

Trees, buildings, and other obstacles also cause a lot of turbulence in the wind. This means that the wind tumbles and swirls around rather than flowing smoothly. Turbulence is particularly bad for wind turbines, because it slows the wind down (reducing kinetic energy in the wind) and also causes a great deal of wear and tear on the turbine. A wind turbine placed in a turbulent wind area would require more maintenance and would have a shorter life span.

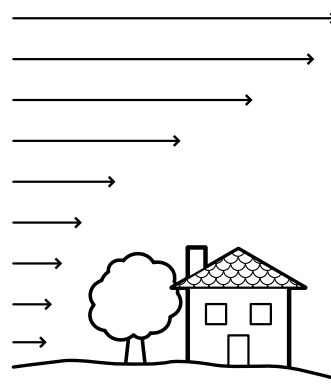
Some inventors and designers are experimenting with “airborne wind turbines.” These giant kite-like wind machines are able to float hundreds of meters above ground level, capturing the strong, smooth winds higher in the atmosphere. They are tethered to the Earth with a cable that also transmits the electricity produced. Though the concept is not yet fully proven, the theory of raising a wind generator higher in the sky while using fewer materials is very promising.

Since wind is the “fuel” for a wind generator, it makes sense to place a turbine where it will receive the most fuel. As wind power expert Mick Sagrillo has been known to say, “Putting a wind turbine on too short of a tower is like putting a solar panel in the shade!” When installing a wind turbine, whether it is a small residential machine or a large industrial turbine, it is very important to build towers tall enough to avoid turbulence and reach high wind speeds.

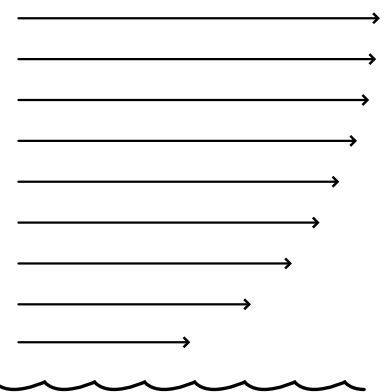
Obstruction of the Wind by a Building or Tree of Height ( $H$ )



Wind shear over obstacles



Wind shear over a flat surface



Objects are scaled to depict wind speed.