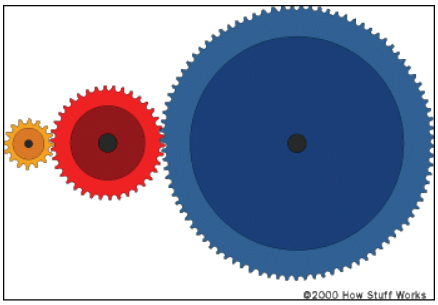
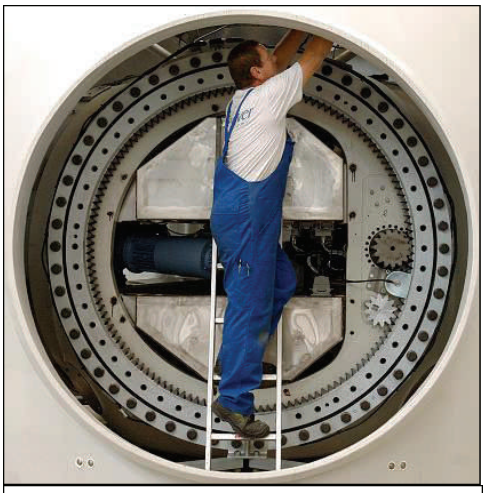
Wind Energy Math Calculations

Gear Ratios



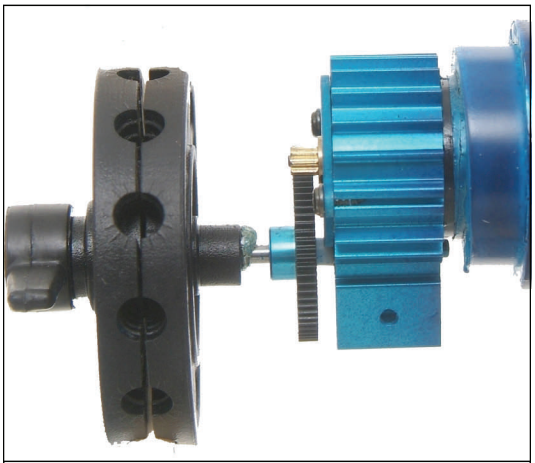
You may have learned about the way an electric generator works: A coil of wire is rotated in a magnetic field to create a flow of electrons. This is the basis of how a wind turbine makes electricity. The blades spin, causing a driveshaft to spin, which in turn rotates the coils in the generator. The problem is that to make the type of electricity we use every day, the generator has to spin VERY fast. To simplify, the faster the coils rotate near the magnet, the more electrons will be pushed along.



Routine maintenance on gears

If you've seen a real utility-scale wind turbine, you probably noticed that the blades spin pretty slowly. So how do they get the generators to spin fast enough? They do this by using gears. You have probably used gears on a bicycle before, so you know how they work. Gears give a wind turbine a *mechanical advantage.* This means that they multiply the mechanical force of the turning blades. This is done by using gears with different numbers of teeth. When the larger gear makes one full revolution, the smaller gear has to spin faster to keep up.

A "Gear ratio" is the relationship between the number of teeth on two or more gears that are meshed. So when you ride your bicycle, the gear in front might have 48 teeth, while the gear in back has 16 teeth. That would mean every time your pedals spin around once, the back wheel spins three revolutions (48/16 = 3). This is called a 3 to 1 (3:1) gear ratio. Wind turbines work the same way except that they have much larger gear ratios. A modern wind turbine may have a gear ratio of 100:1 or more. So every time the blades make one revolution, the generator shaft spins 100 times!



Kidwind Gearbox (6:1 ratio)

Sample Problems:

1. A 1.5 Megawatt wind turbine has 3 blades that spin at 12 RPM. The high speed shaft in the generator is spinning at 1,680 RPM. What is the gear ratio of this wind turbine?

2. A wind turbine has a rated capacity of 2.0 MW. To produce this amount of energy, the generator needs to be spinning at 2100 RPM. If this wind turbine has a gear ratio of 120:1, how fast do the blades need to be spinning to reach the rated capacity?

3. You designed some pretty good blades for your Kidwind geared turbine and they are rotating at 600 RPM. With the 6:1 gear ratio, how fast is the generator spinning? Lets assume hypothetically that the Kidwind motor makes 1 volt for every 790 RPMs of the generator shaft. How many volts is this setup making?

4. The gearbox of a wind turbine is made up of three gears. The largest gear has 1,260 teeth and is meshed to the second gear, which has 70 teeth. The 70 tooth gear is then meshed to the last gear, which has 14 teeth. What is the gear ratio of this wind turbine? If the blades are spinning at 15 RPM how fast is the generator shaft spinning?

Did You Know?
The gear box is usually the heaviest and most expensive parts of a wind turbine. But even though it is so heavy, it has to be housed in the nacelle on top of the wind turbine tower! A typical 1.5 MW wind turbine nacelle can weigh 55 tons or more! It is no easy task to hold a 55 ton box 300 feet up in the windiest locations!