

Wind Turbine Energy Lab

Classroom worksheet · Interactive simulation: <https://lkforge.com/tools/physics/wind-turbine/>

Name: _____ Date: _____

Learning objectives

- Relate wind power to wind speed.
- State the Betz limit on efficiency.
- Identify what affects a turbine's output.

Variables to change

- Wind speed
- Blade pitch
- Rotor size

Procedure

1. Set a moderate wind speed and note the power output.
2. Increase the wind speed and observe how sharply power rises.
3. Adjust blade pitch and rotor size and observe the effect.

Observations

Record power output as wind speed increases and note how strongly they are related.

Questions

1. How does available wind power depend on wind speed?
2. What is the Betz limit?
3. Why can't a turbine extract 100% of the wind's energy?

4. How does rotor (swept) area affect power?

5. Why do turbines pitch or feather their blades in very high winds?

Answer key (instructors)

- **1.** It scales with the cube of wind speed ($P \propto v^3$), so doubling the wind gives eight times the power.
- **2.** The maximum fraction of wind kinetic energy a turbine can extract — about 59.3% (16/27).
- **3.** The air must keep some speed to move on; stopping it completely would block the flow.
- **4.** Power is proportional to swept area, so larger rotors capture more.
- **5.** To limit power and protect the turbine from damage.

Wind power scales with the cube of wind speed and with rotor swept area, but no turbine can capture more than the Betz limit (~59.3%) because the air must keep moving. Blade pitch tunes output and protects the machine in high winds.