How much energy can a wind turbine generate?
http://www.awea.org/faq/wwt_basics.html

Alternative Energy for New Jersey:
The Benefits of Wind Power Development Over the Long Term
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The size of the wind turbine affects cost efficiency. The larger the wind turbine, the greater amount of energy that can be produced at a lower cost. Turbine location is an important factor.

Locating the wind turbine on a site with a minimum of wind disturbances and a maximum amount of wind flow will maximize its efficiency.
Turbine siting and more

The height of the tower is another significant factor. A higher tower reduces obstructions and increases energy output.[39] The higher the tower,the greater the wind speed. Higher wind speeds significantly increase the energy a turbine produces, which in turn diminishes the amount of time whereby the investment can be recovered.[40]

The infrastructure needed for a wind farm includes not only the wind turbines, but also the infrastructure needed to transfer the wind energy from the wind turbine station to where the demand for wind power is located: transmission lines and, in some cases, electrical conversion substations.

Although they are more expensive than land-based wind farms, offshore wind farms are more efficient because they can harness the power of stronger, steadier coastal winds.[63]

Wind Power Map in NYS

Small Turbines and Residential Considerations:
As with any other form of renewable energy, the first factors to investigate are how much energy will be needed for residential use, and whether the home's location is suitable for a wind turbine.[177] After analyzing the amount of energy consumed monthly or annually, reducing the actual consumption should be considered.[178] By replacing low efficiency appliances with high efficiency appliances and at the same time implementing measures to conserve energy, the need for electricity can be significantly decreased, thereby reducing the amount of overall energy, including wind energy, necessary to meet energy needs. Reducing energy consumption means that a smaller, less costly turbine can be used.[179] Moreover, the location of a home may not be conducive to supporting a wind turbine. To gauge whether a home is situated in an area that can support a wind turbine, long-term average wind speeds or historic climate data, rather than day-to-day weather patterns, need to be considered.[180]

Even though small wind turbines are very cost effective, they have mechanical systems that require maintenance. Smaller wind turbines have an average life span of at least 20 years and will periodically require maintenance or repairs.

Other cost considerations a homeowner should consider include: (1) how much electricity is offset by the wind system; (2) net metering (or, rather, the method of metering the amount of energy a home or business consumes, where such home or business has a wind turbine or other renewable energy generation source; with net metering, if a wind turbine produces excess electricity, the home or business's electricity meter will spin backwards, so that such excess electricity is effectively "banked" for the consumer) or sold back to the utility183; (3) cost of equipment and reliability; (4) installation costs; (5) insurance; and (6) revenue gained from excess generation, (5) consumer economic rebates and incentives. 184

Methods for Surviving High Winds
A turbine can heat up and be damaged by excessive wind speeds.
To avoid this various methods can be employed:

1. variable pitch blades
2. a furling tail
3. mechanical and air brakes
4. flexible twisting blades
5. emergency shut down.

small wind turbine basics

Unless you are working with a tiny 'science fair project' windmill that is capturing wind from an electric fan, some sort of regulation is needed or bits **will** fall off! Beware of any wind turbine whose builder claims that it doesn't need to furl because it is built so sturdily (tested to 100+mph!). But how many times and for how long can it withstand such abuse? Also beware if the builder advises you to lower the turbine to the ground if high winds are forecast—it probably lacks a shutdown system.

Types of Wind Turbines

Drag Turbines

- a cup or blade is pushed by wind
- less efficient b/c ½ blades are going against the wind
- blades can only go as fast as the air

Lift Turbines

- use an airfoil blade like a propeller to create lift and push on the blades
- can rotate *faster* than the wind and get more power

VAWTs (vertical axis wind turbines)

- blades spin parallel to ground, axis is vertical
- less efficient b/c ½ blades are going against the wind
- must be twice as big as HAWT to generate same power

HAWTs (horizontal axis wind turbine)

- blades move perpendicular to the ground, rotor axis is horizontal
- most common, efficient design for most purposes.

HAWT Blade Design

- Blades are wider at the base to catch more wind. Blades are thinner at tips to lower mass and increase rotation speed.
- Blades are tilted with respect to wind direction to generate lift
- Blades are twisted so that the angle of attack is lower at the tips where tip speed is greater. Greater wind speed requires lower angle of attack.
- As the area of blades increases with respect to the sweep area (this is called "solidity"), the torque increases but the tip speed decreases, and rpm drops. To generate electricity rpm are more important than torque; therefore, low solidity is preferred.
- The best number of blades and optimum blade speeds can be calculated

Tip Speed Ratio (TSR)

TSR should not be too high or too low for maximum power generation.
wind energy math calculations

TSR = speed of blades/ speed of wind
* make sure that speeds are in the same units (m/s or mph, etc…)

To determine speed of blades…

Velocity = distance / time

Velocity = circumference of sweep area ($2\Pi r$) / time for one turn (60/rpm)

A TSR>1 means you have LIFT in your blades (good). A TSR<1 means you have a drag turbine that can never spin faster than the wind (bad).
Modern wind turbines have TSR around 5!

The optimum TSR = 4Π / n (where n = number of blades)

Coefficiency of Power (Cp)

Divide the turbine's electrical power output by the wind energy input.

A Power Coefficient Curve shows the Cp at various wind speeds.
Turbines are engineered to have maximum efficiency at speeds that provide the most power.

check out a power coefficient curve

Power of the Wind = $\frac{1}{2} * p * A * V^3$

p= density of air 1.2 kg/cubic meter
V = wind velocity
A = sweep area ($\Pi * r^2$) sweep area

Power of electrical output = volts * amps

The Gear Box

Blades spin slowly, but the generator must spin fast.
This is accomplished by using gears.
gear ratios = # teeth gear 1 / # teeth gear 2

Modern turbines house the gear box in the nacelle and have ratios as high as 100:1
The gear box is the heaviest and most expensive part of the turbine.

Other considerations:

- Grounding your tower against lightning strikes on or near the tower.
- Tower base and guy line support
- How will you erect the tower?
- Safety. A wind turbine creates serious risk of accident, damage, and injury.
- Community sentiment.

Check out this webpage and write a short paragraph that expresses some of the concerns that communities have about large scale wind farms in their environment.

http://cohoctonwindwatch.blogspot.com/