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Renewable Energy generation
Micro Wind

Renewable energy generation
Wind

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- Installed with battery or another generation source
- Provides intermittent supply but can meet night loads
- Need dedicated technicians

Renewable energy generation
Wind

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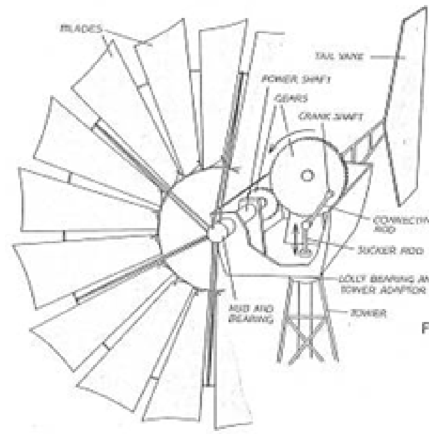
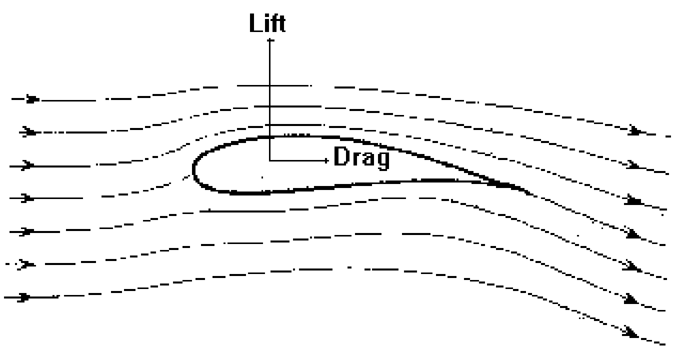
- Old-fashioned windmills use DRAG (pushed by the wind) but modern wind turbines use LIFT



From: *The Wind Power Book*, by Jack Park

- When air flows past the blade, a wind speed and pressure differential is created between the upper and lower blade surfaces.

- The pressure at the lower surface is greater and thus acts to "lift" the blade. When blades are attached to a central axis the lift is translated into rotational motion.



Renewable energy generation
Wind

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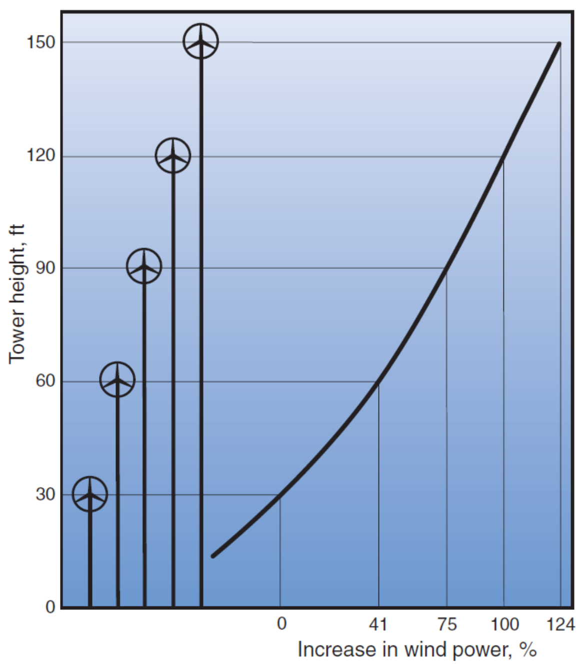
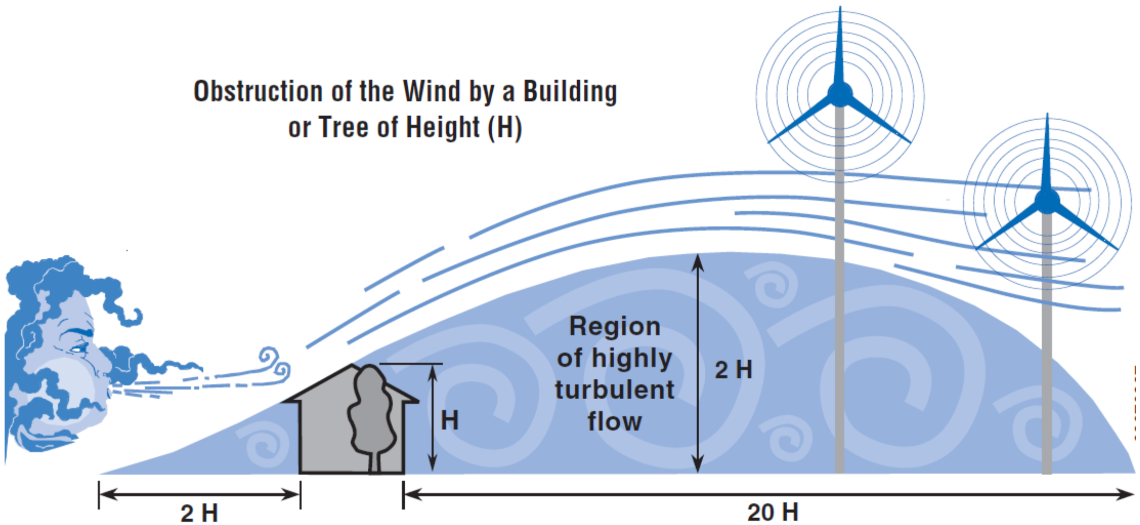
Wind Speeds Increase with Height





Renewable energy generation
Wind

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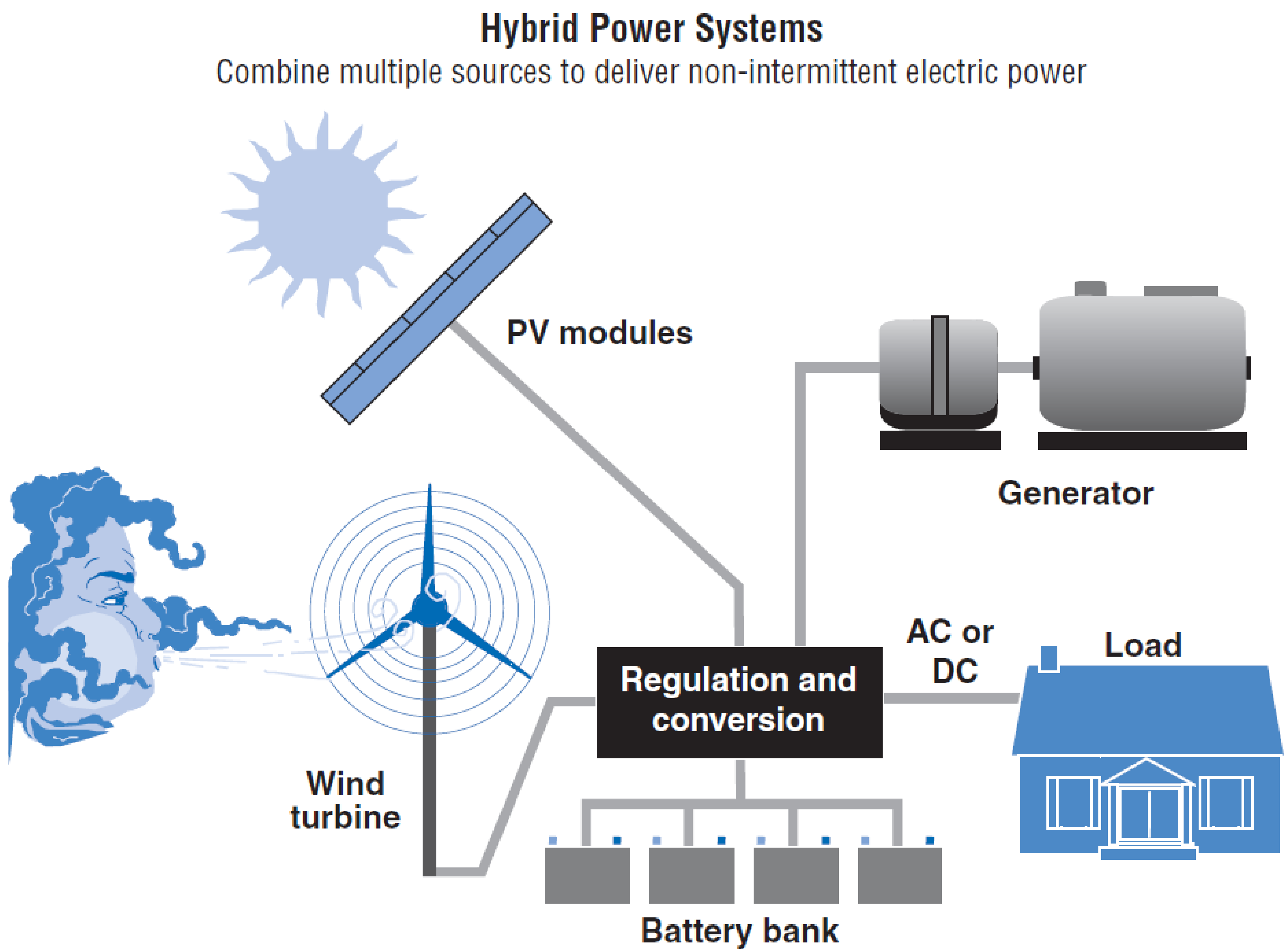

Renewable energy generation
Wind

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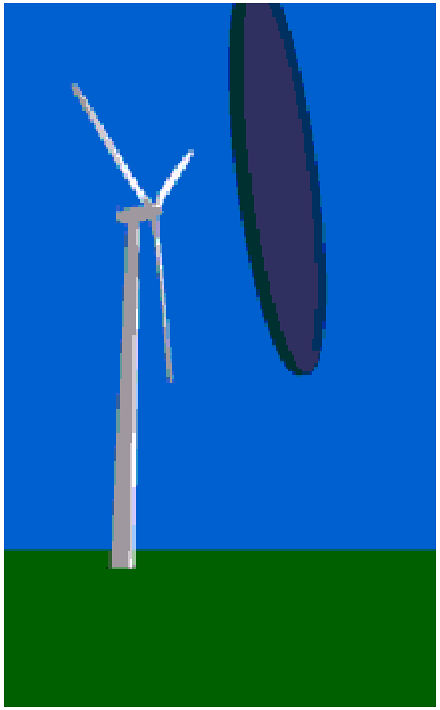
A wind turbine obtains its power input by converting the force of the wind into a **torque** (turning force) acting on the rotor blades. The amount of energy which the wind transfers to the rotor depends on the density of the air, the rotor area, and the wind speed.

A cylindrical slice of air 1 metre thick moves through the 1500 m^2 rotor of a typical 600 kilowatt wind turbine. With a 43 metre rotor diameter each cylinder actually weighs 1.9 tonnes, i.e. 1,500 times 1.225 kg.



Renewable energy generation
Wind

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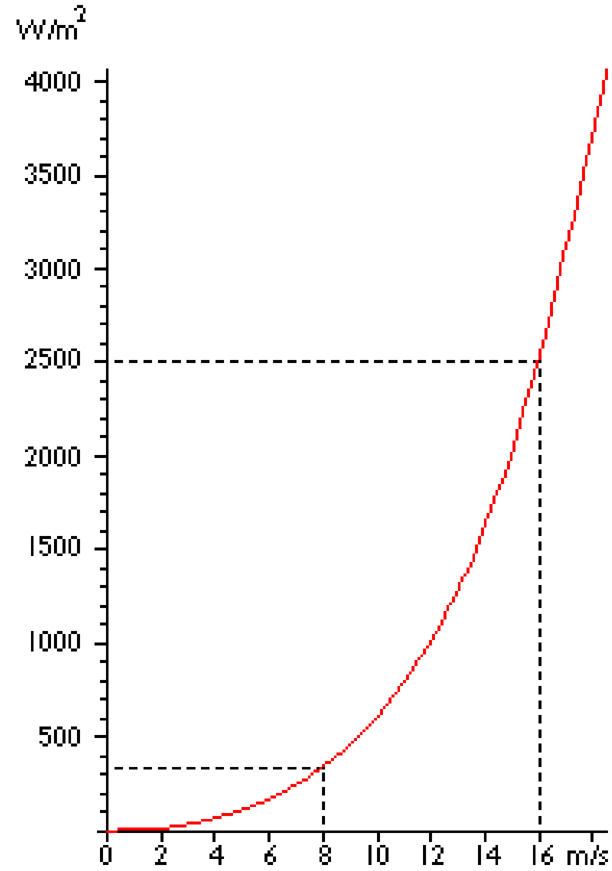
Power in the wind (W) is given by:

$$P = \frac{1}{2} \rho A v^3$$

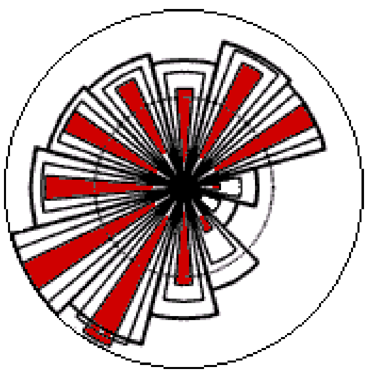
ρ = (rho)=density of dry air=1.225Kg/m^3
A area of the rotor area = πr^2
v is the wind speed in ms^{-1}



Power is *proportional* to the *third power* of the wind speed; the power increases eightfold when the wind speed doubles

Case studies- microwind

5 ms^{-1} is considered the minimum wind speed to be economically viable.



Note, that the energy content of the wind varies with the cube of the wind speed. So *the red wedges are really the most interesting ones. They tell us where to find the most power to drive wind turbines.* In the above case one can see that the prevailing wind direction is Southwest

A wind rose gives you information on the relative wind speeds in different directions, i.e.each of the three sets of data (frequency, mean wind speed, and mean cube of wind speed) has been multiplied by a number which ensures that the largest wedge in the set exactly matches the radius of the outermost circle in the diagram.

Case studies- microwind

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- If a large share of the energy in the wind comes from a particular direction, then you will want to have as few obstacles as possible, and as smooth a terrain as possible in that direction, when you place wind turbines in the landscape.
- In the previous windrose example most of the energy comes from the Southwest. We therefore need not be very concerned about obstacles to the East or Southeast of wind turbines, since practically no wind energy would come from those directions.
- You should note, however, that wind patterns may vary from year to year, and the energy content may vary (typically by some ten per cent) from year to year, so it is best to have observations from several years to make a credible average.

Case studies- microwind

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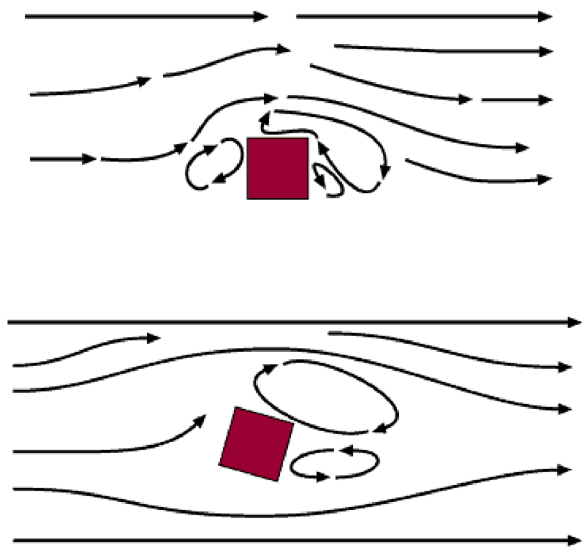
- Obstacles to the wind such as buildings, trees, rock formations etc. can decrease wind speeds significantly, and they often create turbulence.

- As you can see from this drawing of typical wind flows around an obstacle, the turbulent zone may extend to some three time the height of the obstacle. The turbulence is more pronounced behind the obstacle than in front of it.

- Therefore, it is best to avoid major obstacles close to wind turbines, particularly if they are upwind in the prevailing wind direction, i.e. "in front of" the turbine



Small wind generators

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20 kW or less
May be connected to the electrical grid or “stand alone” in a remote location
May have batteries
$10,000 - $75,000
Generate AC or DC
Face upwind or downwind

A typical small wind generator has a rotor which is directly coupled to a generator which produces electricity either at 120/240 volt alternating current for direct domestic use or at 12/24 volt direct current for battery charging.

A tail vane keeps the rotor orientated into the wind. Some wind-machines have a tail vane which is designed for automatic furling (turning the machine out of the wind) at high wind speeds to prevent damage

Turbine output

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To determine how much power is available on a daily basis. The Annual Energy Output must be divided by 365 days to give the Daily Energy Output. For the purposes of battery based system design this Daily Energy Output must be divided by the System Voltage to give the Daily Amp-Hours.

Example. In a 12 volt system, where the average annual wind speed is 10 mph, the AIR 303 micro-turbine will produce 140 kWh.

Daily Energy Output = 140 kWh /365 days
= 383 watt hours/day

Daily Amp Hours = 383/12 volts
= 2 amp hours per day

Therefore, if you have an energy budget of 32 amp-hours per day the Air 303 will supply the power you require at an average annual wind speed of 10 mph

Estimating wind resource

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- Could Measure the wind speed over a period of a year at locations expected to be suitable. i.e. Elevated and clear
    - Should be measured at the height of proposed turbine
- Wind resource maps are available which use wind station observations combined with numerical modelling
- Data can be treated in a similar way to solar (clustering analysis)
- Various dataset websites
    - European Reanalysis (ERA)-Interim reanalysis database

Evaluating design options

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HOMER is a computer model that simplifies the task of evaluating design options for both off-grid and grid-connected power systems for remote, stand-alone, and distributed generation (DG) applications. HOMER's optimization and sensitivity analysis algorithms allow you to evaluate the economic and technical feasibility of a large number of technology options and to account for variation in technology costs and energy resource availability. HOMER models both conventional and renewable energy technologies