
Wind Turbine
Energy

HISTORY

The first wind-mills were developed in Persia and probably in Chaina between 500-900 B.C to automate the tasks of water-pumping and grain grinding .
From there the use of wind-mills spread from Persia to the surrounding areas in the middle east , where it was used in food production.

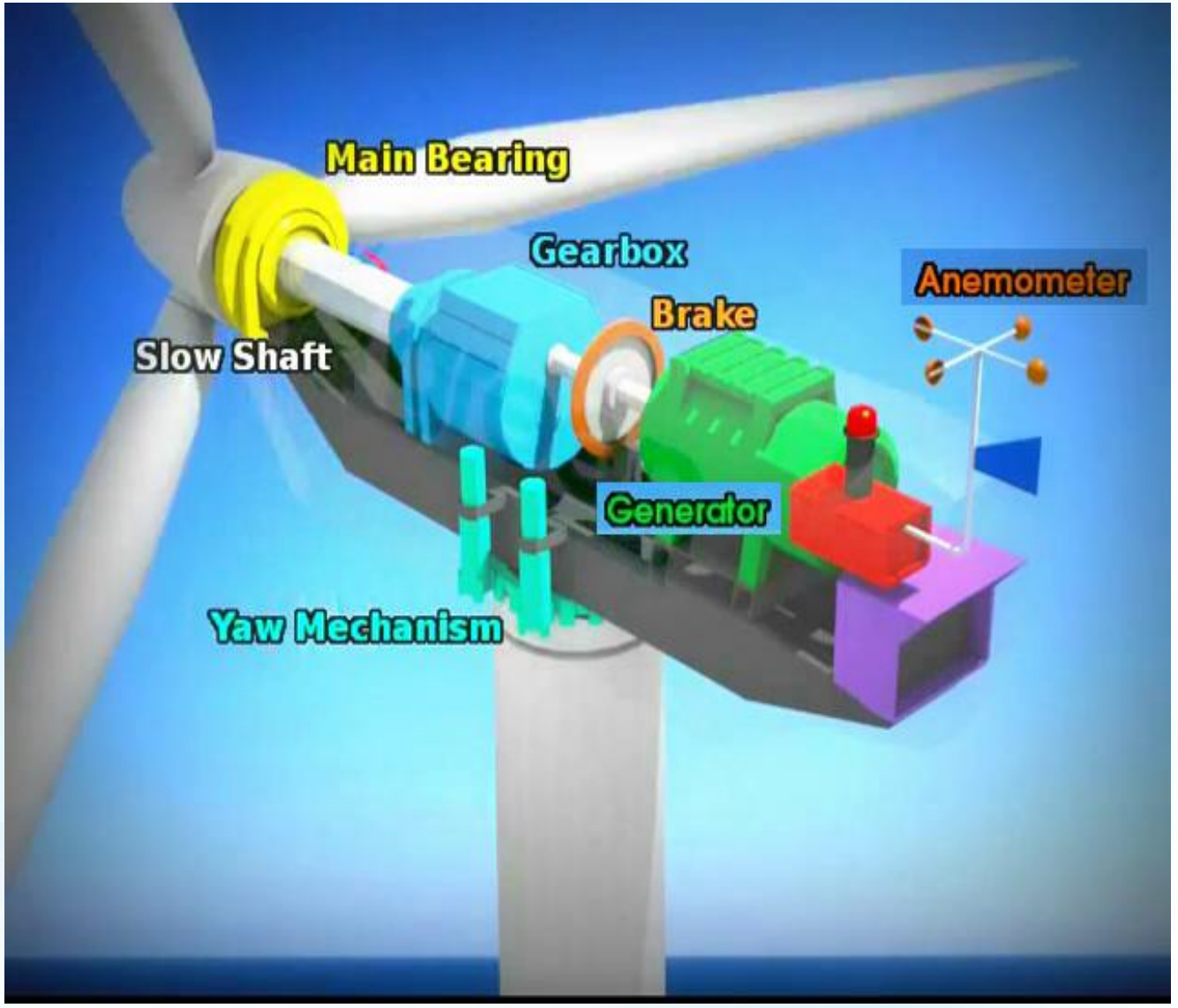
Around 1,000 A.D., wind power technology spread north to European countries such as The Netherlands, which adapted windmills to help drain lakes and also to grind grain, with a new design for the wind mill – a tower mill.

The technology developed between 1850 and 1970, over six million mostly small (1 horsepower or less) mechanical output wind machines were installed in the U.S. alone.

INTRODUCTION

- Wind turbine is a device that converts kinetic energy from the wind into electric power.
- Wind energy is created when the atmosphere is heated unevenly by the Sun, some patches of air become warmer than others. These warm patches of air rise, other air rushes in to replace them thus, wind blows.
- It works opposite of fan turbine blade spin from the wind and make energy instead of using energy to make wind.
- The first windmill used to produce electric energy was created in 1888 by Charles F. Brush.
- The wind power programme in India was started during 1983-84 with the efforts of the Ministry of Non-Conventional Energy Sources.

Components of wind turbine



Function of Component

Foundation: Foundation give support to wind turbine. It consist of solid concrete assembly

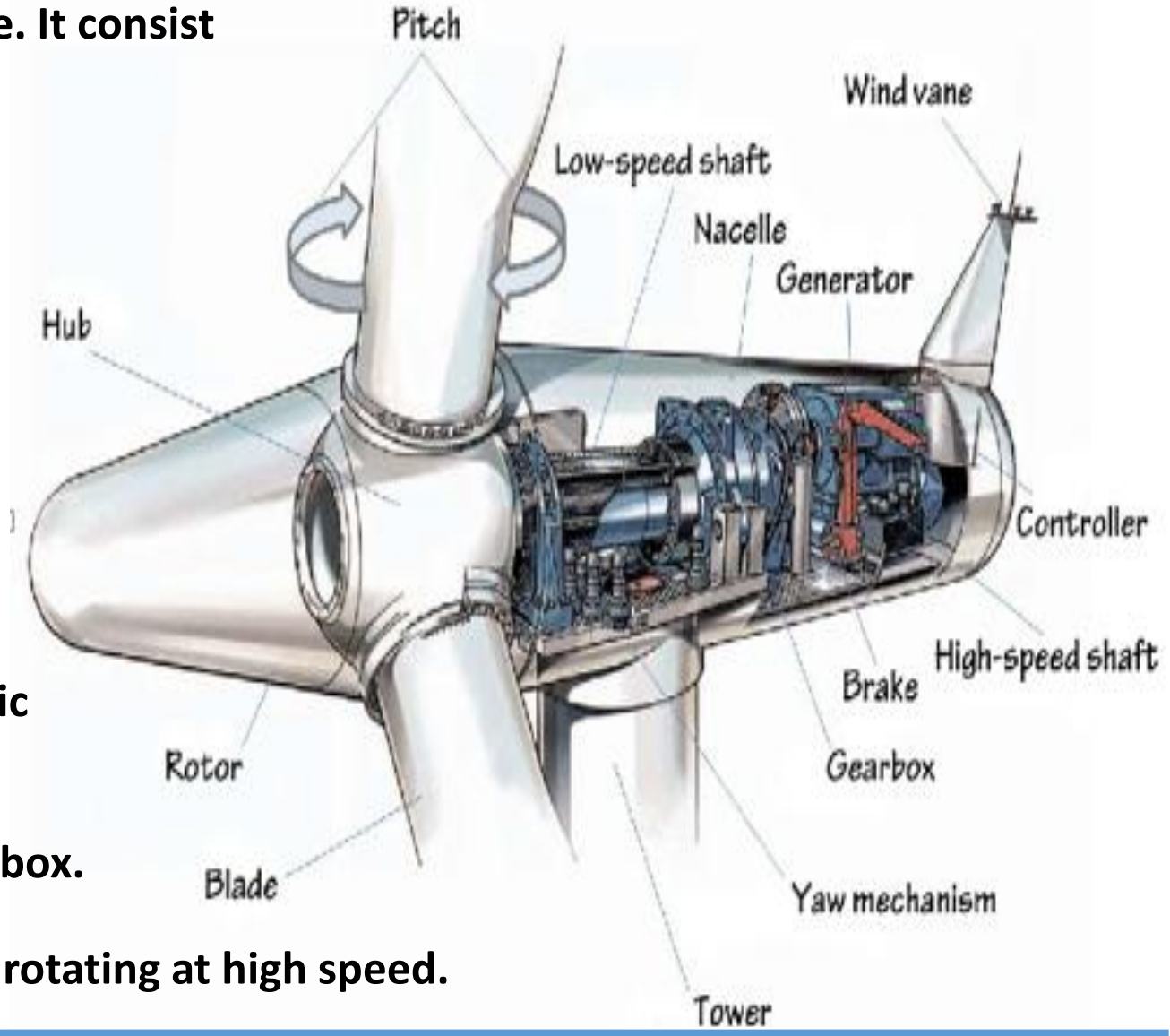
Tower : It connect rotor and foundation and raise rotor so that it can operate at required wind. Made up of steel having tube like structure.

Rotor & Rotor blades : It is rotating part which converts wind energy to rotation. It is made up of glass-fibre, carbon-fibre, reinforced plastics.

Nacelle : Contains the key components of the wind turbine including the gearbox , yaw system and electric generator

Low speed shaft: Connects the rotor hub to the gearbox.

High speed shaft : Drives the electrical generator by rotating at high speed.



Function of Component

Gearbox :- The gearbox converts the rotor motion of lower rpm into the higher rpm.

Coupling :- Coupling is done between the main shaft and the transmission.

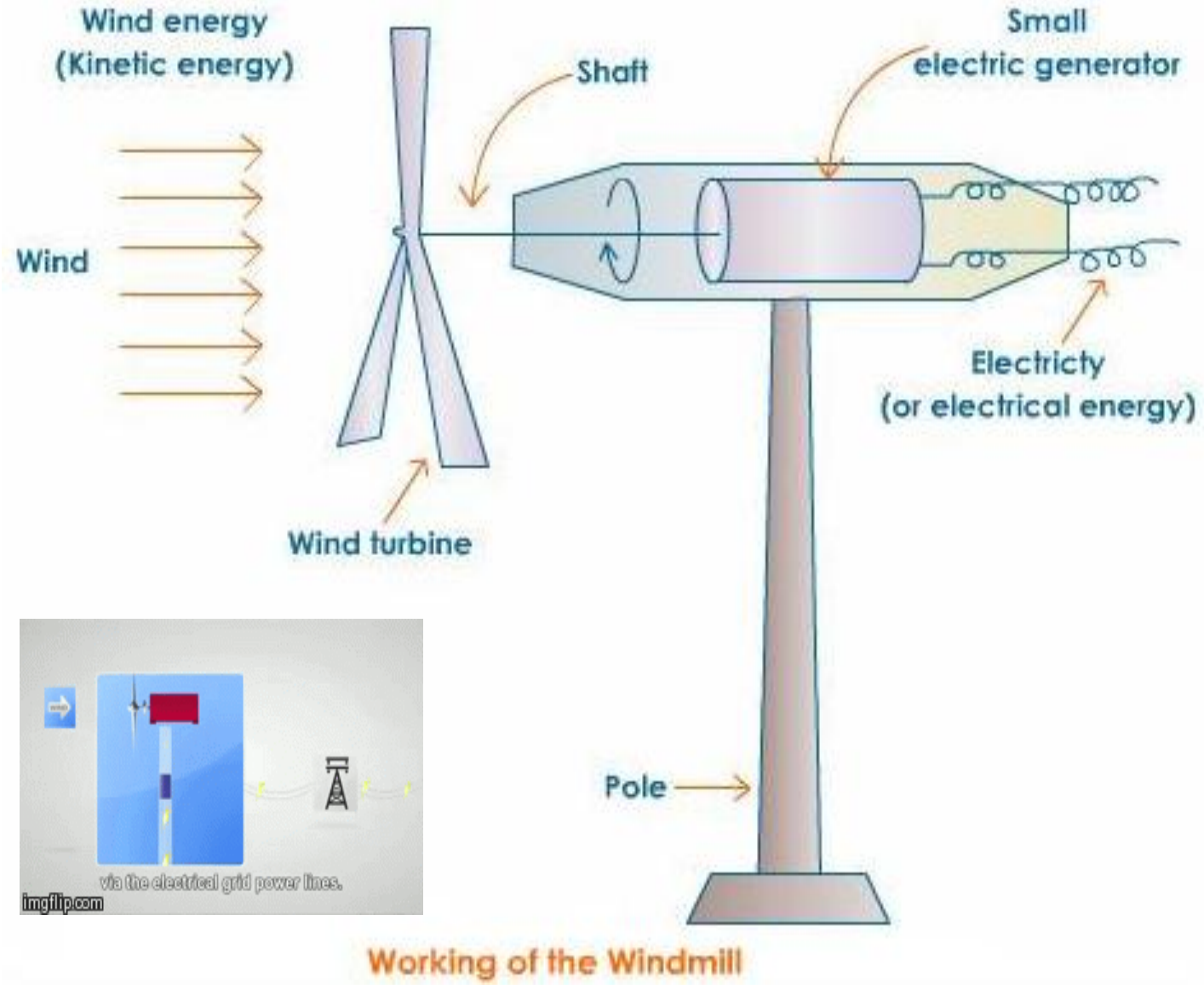
Generator :- Generates electricity from rotation of shaft.

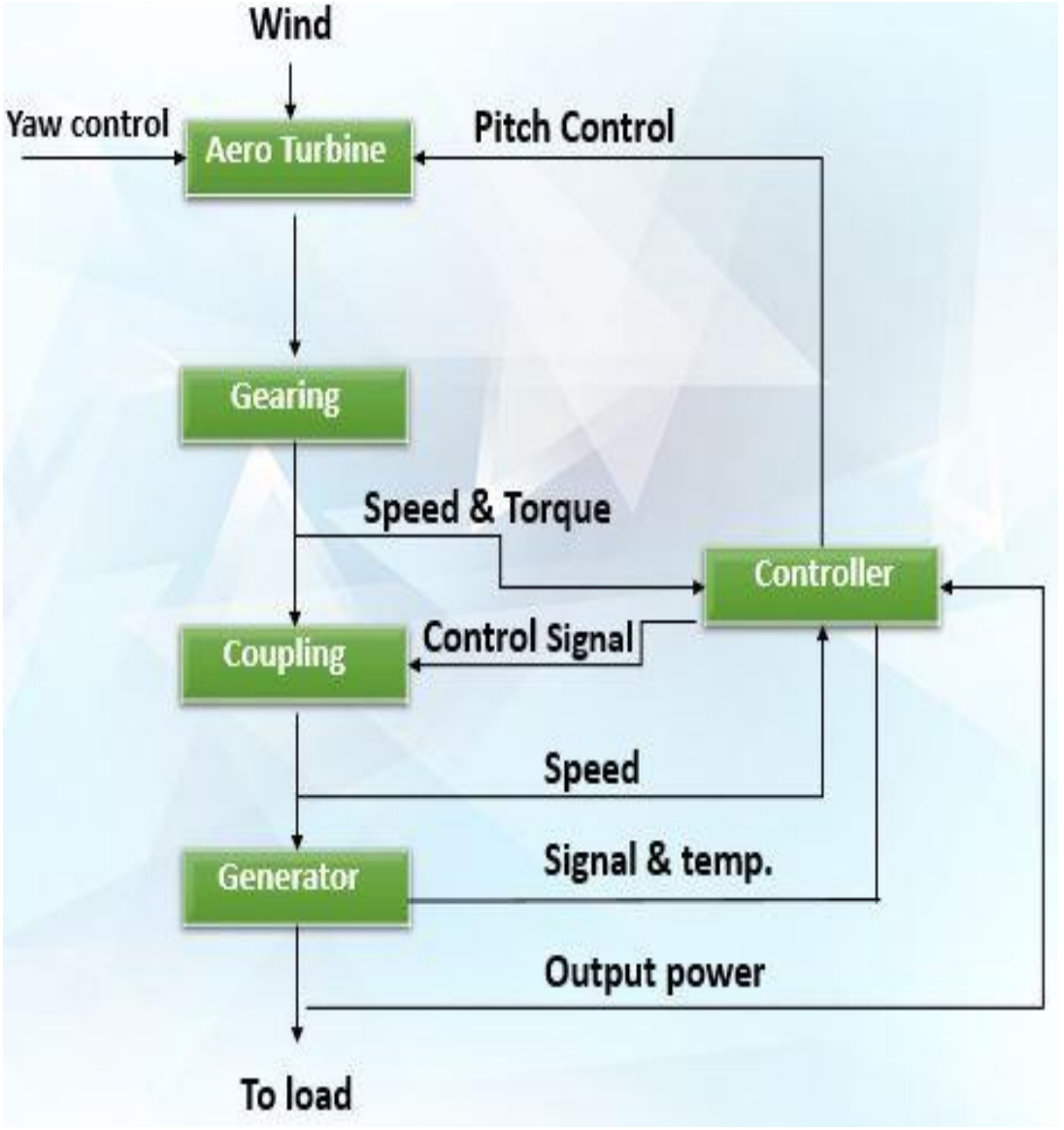
Controller :- It is a self operating system use in control system. It may be sensor (mechanical, electrical), decision elements(relays, microprocessor) and actuators(hydraulic, electric).

Yaw mechanism :- Turns the nacelle with the rotor into the wind using motors.

Anemometer and wind vane :- Measures the speed and the direction of the wind while sending signals to the controller to start or stop the turbine.

Working


Wind energy
(Kinetic energy)
Wind
Shaft
Small
electric generator
Electricty
(or electrical energy)
Wind turbine
Pole
via the electrical grid power lines.
imgflip.com
Working of the Windmill


Wind
Yaw control
Aero Turbine
Pitch Control
Gearing
Speed & Torque
Controller
Coupling
Control Signal
Speed
Generator
Signal & temp.
Output power
To load

Types of wind turbine

1. Horizontal axis type

A horizontal axis machine has its blades rotating on an axis parallel to the ground.

Single blade Horizontal wind turbine	Two blades Horizontal wind turbine	Three blades Horizontal wind turbine
Lower blade weight and less cost. More vibration & unconventional look.	Similar to single blade HAWT. Have stability problem	Balance of gyroscopic forces increases gearbox costs

Types of wind turbine

2. Vertical axis type

Vertical axis wind turbines(VAWTs) have the main rotor shaft arranged vertically.
VAWTs runs in any wind direction.

Darrieus wind turbine	Savonius wind turbine
Good efficiency Produce large torque and cyclic stress on the tower Require some external power source to start turning 	drag type turbine used in cases of high reliability in many things such as ventilation and anemometers. self starting less efficient 

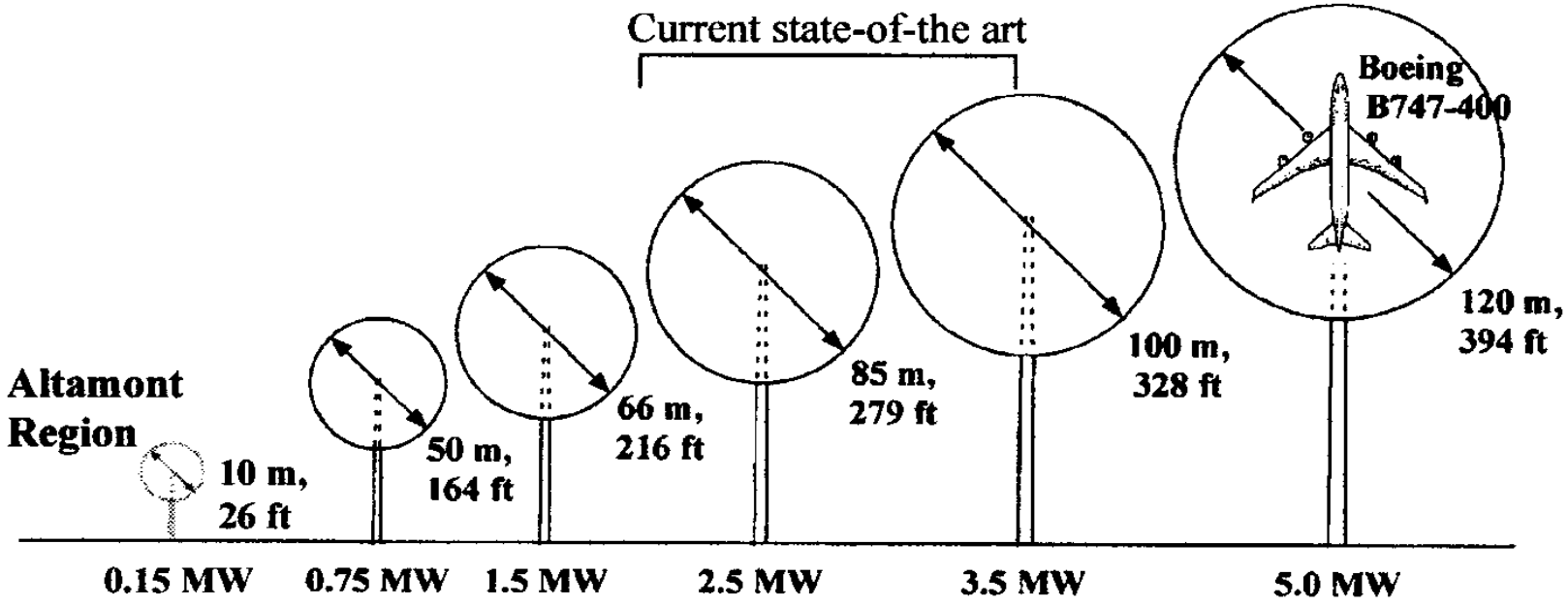
Size of wind turbine

Small (≤10 kW)
- Homes
- Farms
- Remote Applications

(e.g. water pumping, telecom sites,)

Intermediate (10-250 kW)
- Village Power
- Hybrid Systems
- Distributed Power

Large (250 kW - 2+MW)
- Central Station Wind Farms
- Distributed Power



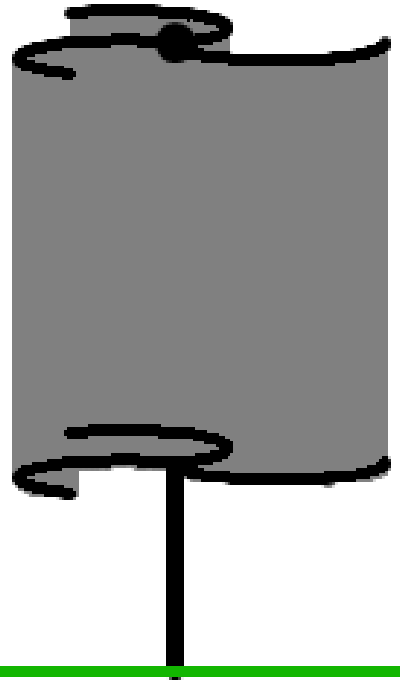
Small scale wind turbines

Are they worth it, energy-wise?

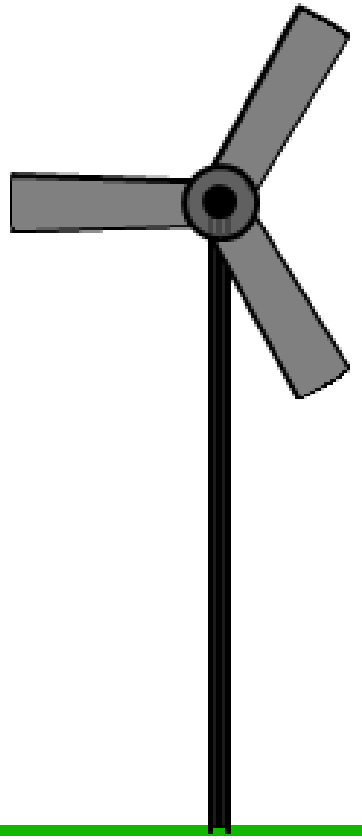
Energy and Sustainability

Types of small-scale wind turbines

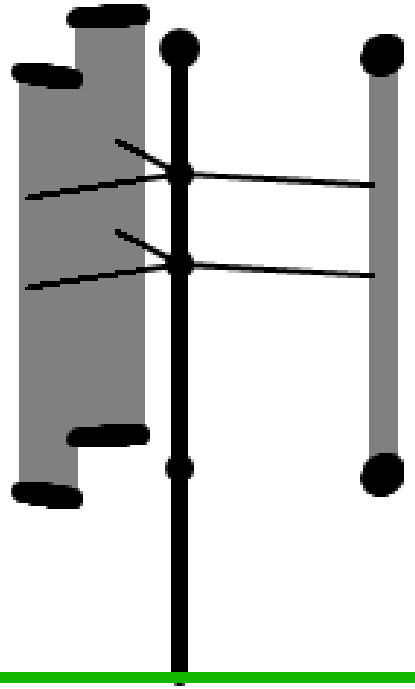
- Horizontal axis wind turbine (HAWT)
- Vertical axis wind turbine (VAWT)



Savonius VAWT



Modern HAWT



Giromill/Darrieus VAWT

Anemometer

Types of small-scale wind turbines

HAWT

- Main rotor shaft and electrical generator at the top of the tower
- Must be pointed into the wind

VAWT

- Main rotor shaft arranged vertically
- The generator and gearbox can be placed near the ground
- Does not need to be pointed into the wind
- Relatively low rotational speed

Gross power small scale wind turbines

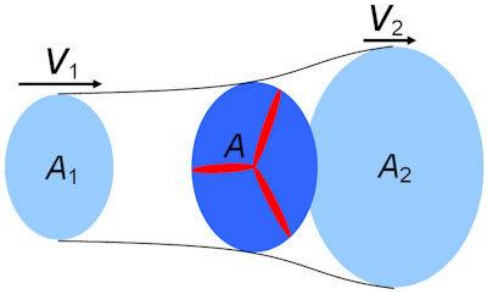
$$P_G = \frac{1}{2}\rho A u^3 e$$

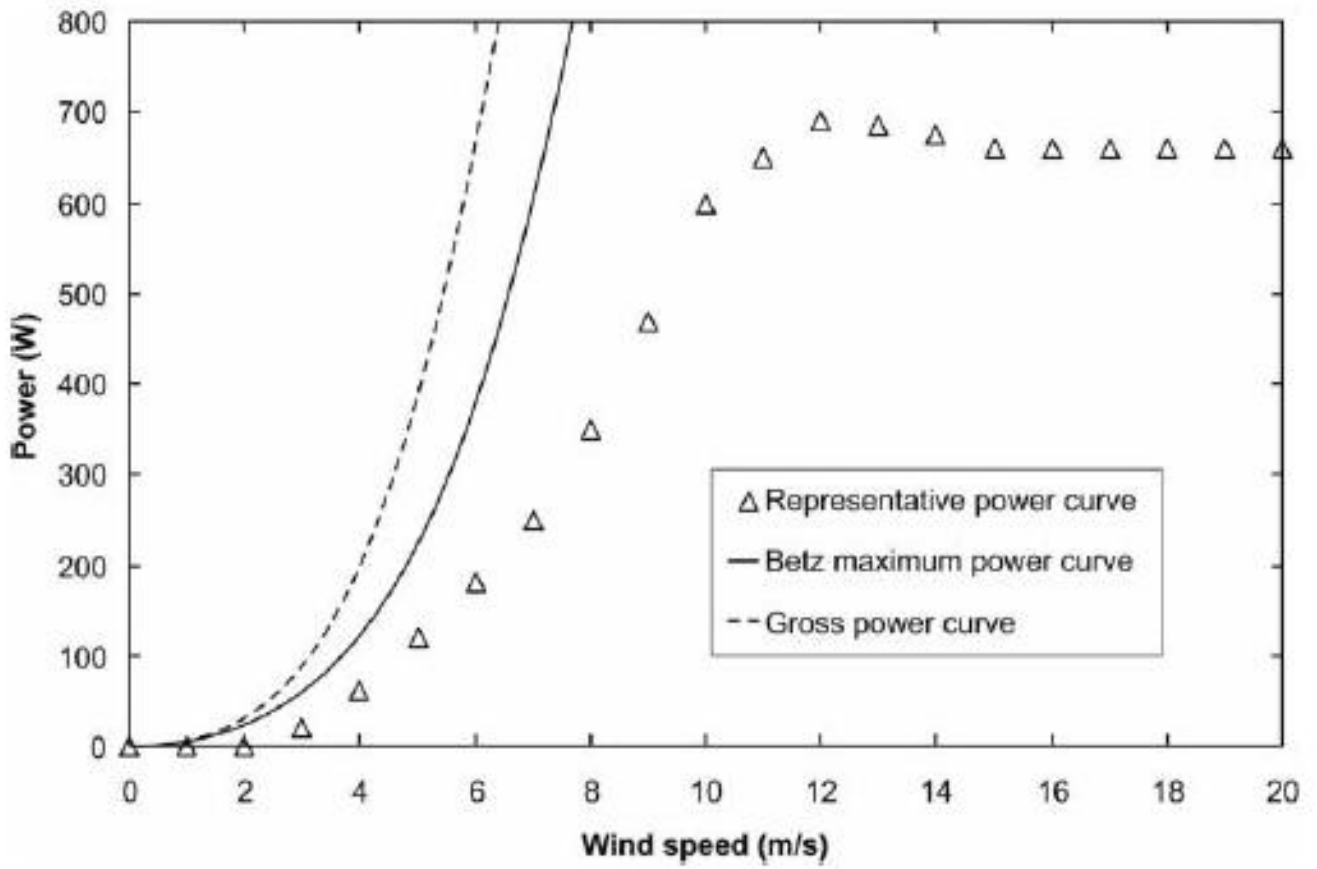
- $A = \frac{\pi}{4} D^2$
- D – rotor diameter
- ρ – air density
- u – wind velocity

[Sahin *et al*. 2006]

Power limit small scale wind turbines

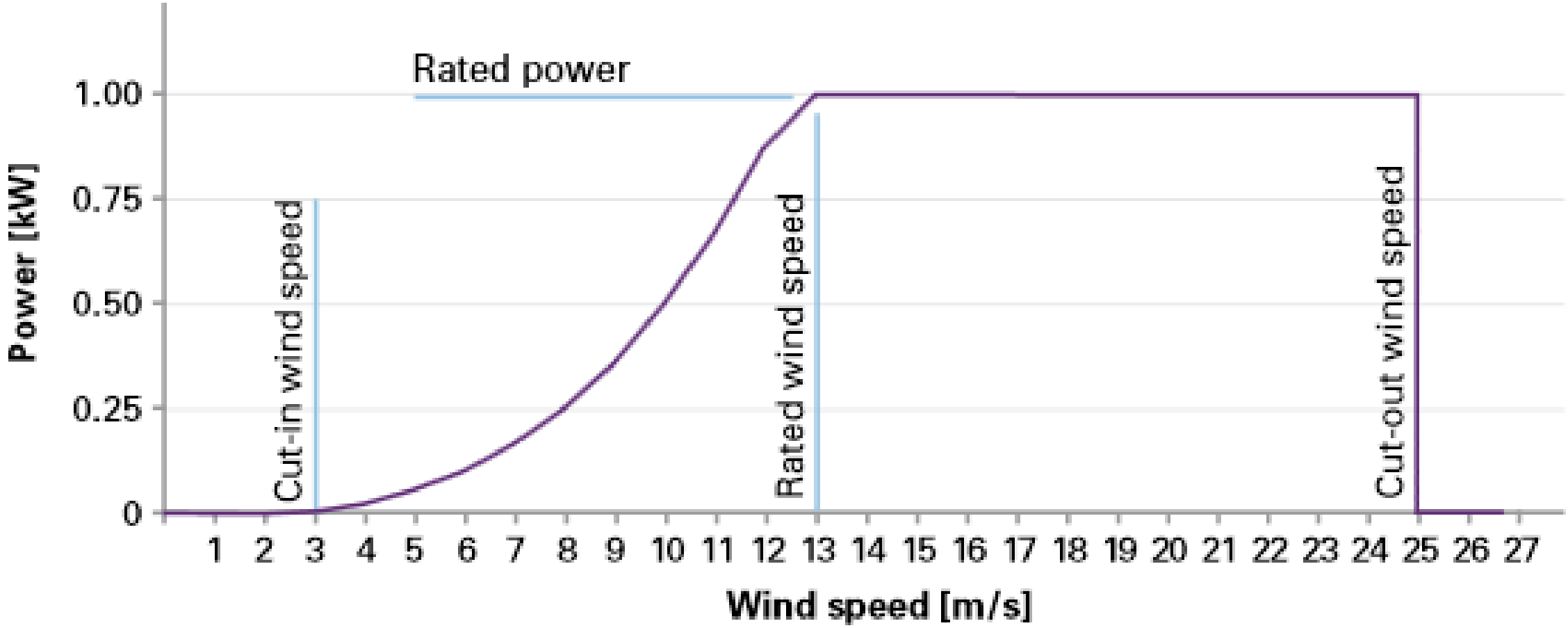
Betz limit - Max power of 59%





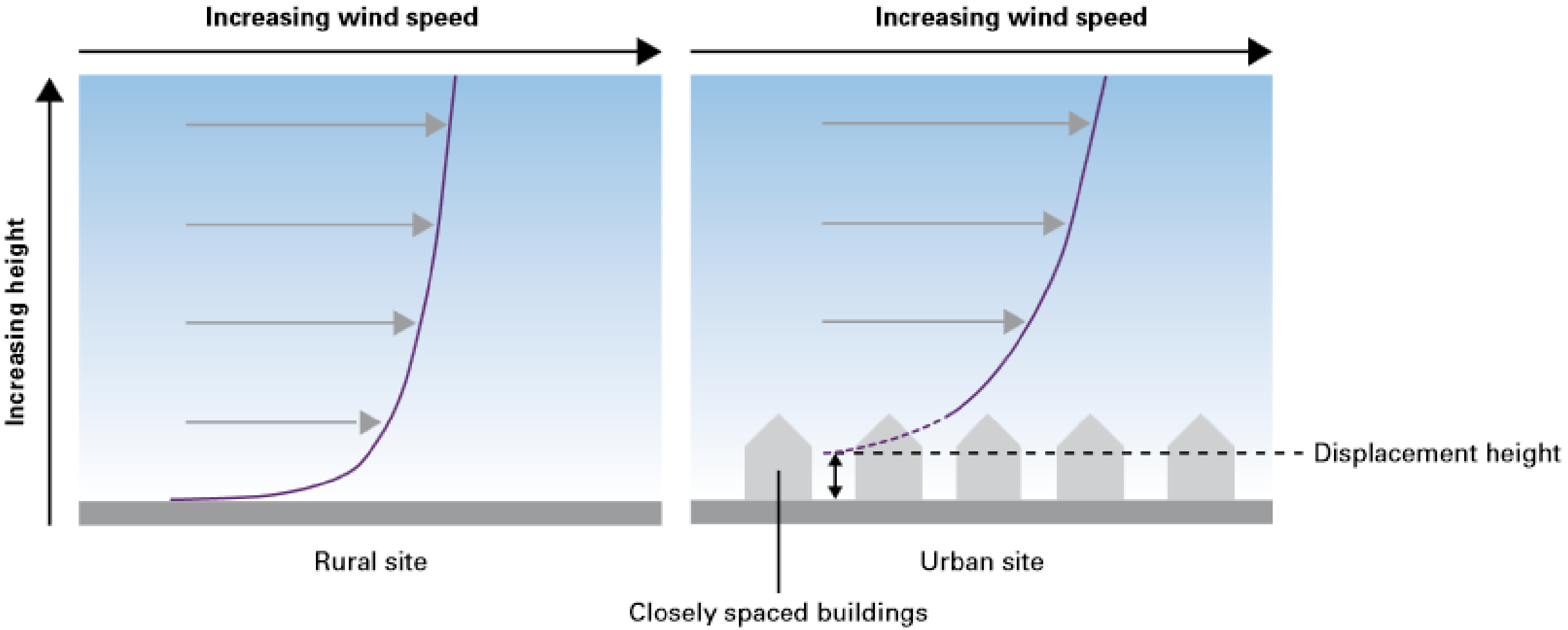
[Betz 1946]

Power curve small scale wind turbines



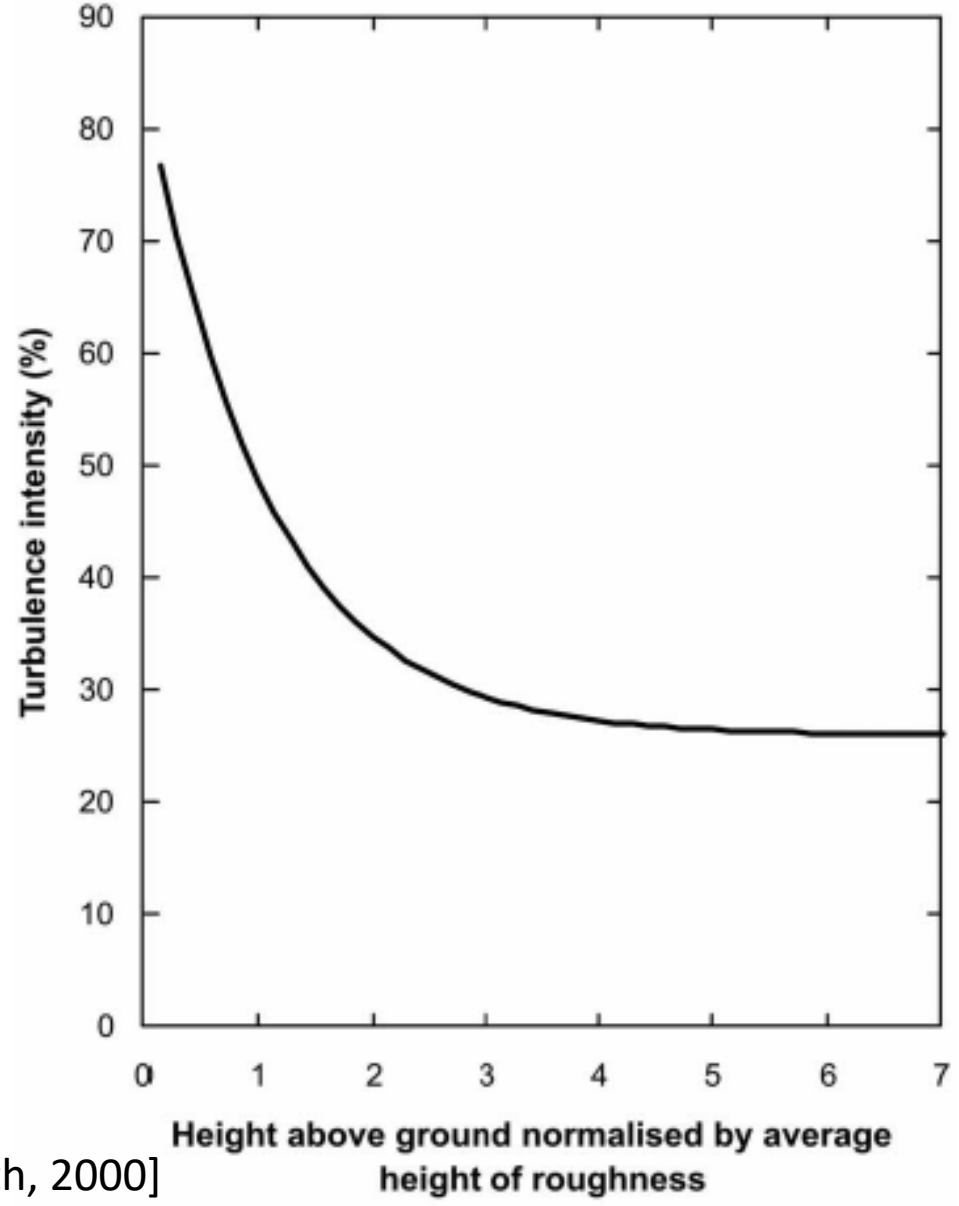
[Entec]

Wind resource small scale wind turbines



[Entec]

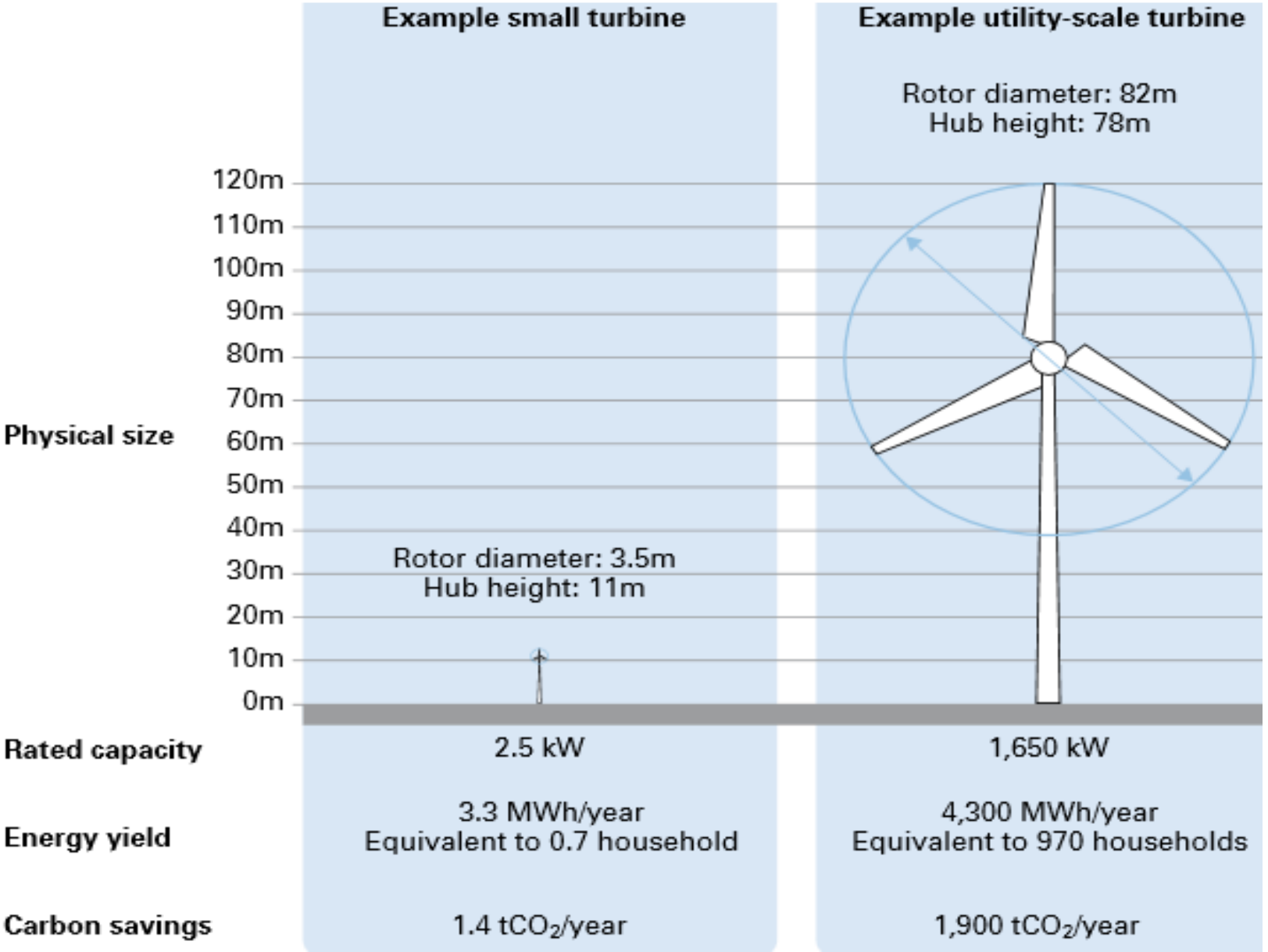
Turbulence small scale wind turbines



[Roth, 2000]

- Rated power of less than 50kW

Comparison small scale wind turbines



	micro HAWT	Swift rooftop wind turbine
Power rating (kW)	0.6	1.5
Mean annual output (kWh)	870-164	2000 - 3000
Rotor diameter (m)	1.7	2
Lifetime (y)	15	20
Rated velocity (m/s)	12	12

[Carbon trust]

The performance of wind turbines depend on 5 major factors:

OBSTRUCTIONS

WIND POWER

ALTITUDE

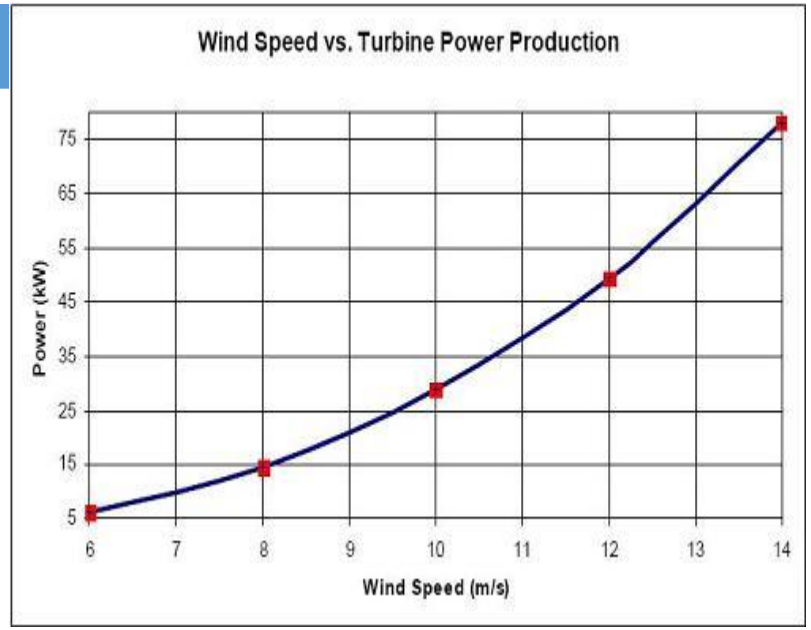
AIR TEMPERATURE

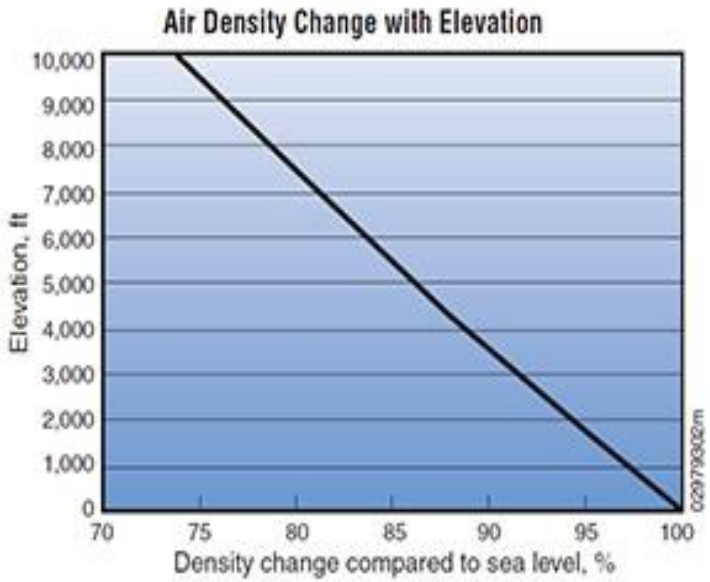
BLADE AERODYNAMICS

Site Selection

Consideration during site selection

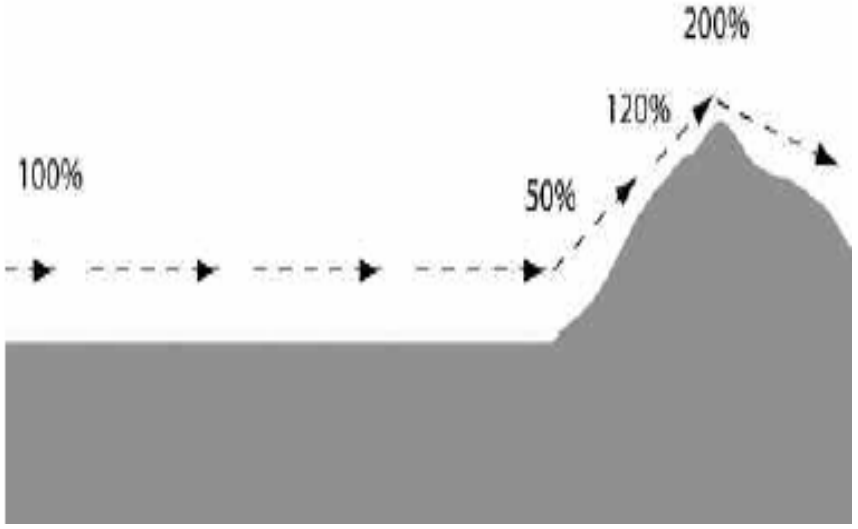
- High annual average wind speed
- Altitude of proposed site
- Terrain and aerodynamic
- Ease of transportation
- Nearness to users/centers
- Local ecology & Nature of ground





Best sites for wind turbine

- Off shore and sea coast (2400 kWh/m^2 per year)
- Mountains (1600 kWh/m^2 per year)
- Planes (750 kWh/m^2 per year)



Wind farms

A wind farm or wind park is a group of wind turbines in the same location used to produce energy.

Offshore wind farms

Wind farm located right off the coast or in sea using floating platform.

More wind power but more cost.

London Array, United Kingdom (630 MW)

Onshore wind farms

Less wind power available than offshore.

Less cost in installation.

Usually near to user but create noise and visual problems.

Jaisalmer wind park, Rajasthan (1064 MW)

Location of wind farm

Worldwide there are now over **two hundred thousand** wind turbines operating, with a total nameplate capacity of **318,105 MW.**

Top 10 countries by nameplate wind power capacity

Country	New 2013 capacity (MW)	Windpower total capacity (MW)	% world total
China	16,088	91,412	28.7
United States	1,084	61,091	19.2
Germany	3,238	34,250	10.8
Spain	175	22,959	7.2
India	1,729	20,150	6.3
UK	1,883	10,531	3.3
Italy	444	8,552	2.7
France	631	8,254	2.6
Canada	1,599	7,803	2.5
Denmark	657	4,772	1.5
(rest of world)	7,761	48,332	15.2
World total	**35,289 MW**	**318,105 MW**	**100%**

wind energy installations in states across India

State	Capacity as on 31.03.2014(MW)[14]
Tamil Nadu	7253
Gujarat	3414
Maharashtra	2976
Rajasthan	2820
Karnataka	2409
Andhra Pradesh	753
Madhya Pradesh	439.00
Kerala	55
Others	4.30
Total	**21264**

Safety System

Emergency stop :- If a situation arises which calls for the wind turbine to be stopped immediately, it is used and wind turbine stop in few seconds by feathering the blade directly into the wind.

Computer and sensors :- The wind turbine is controlled by a computer and data from sensors which monitors the most important gauging instrument and compare the result , if found error wind turbine is stopped.

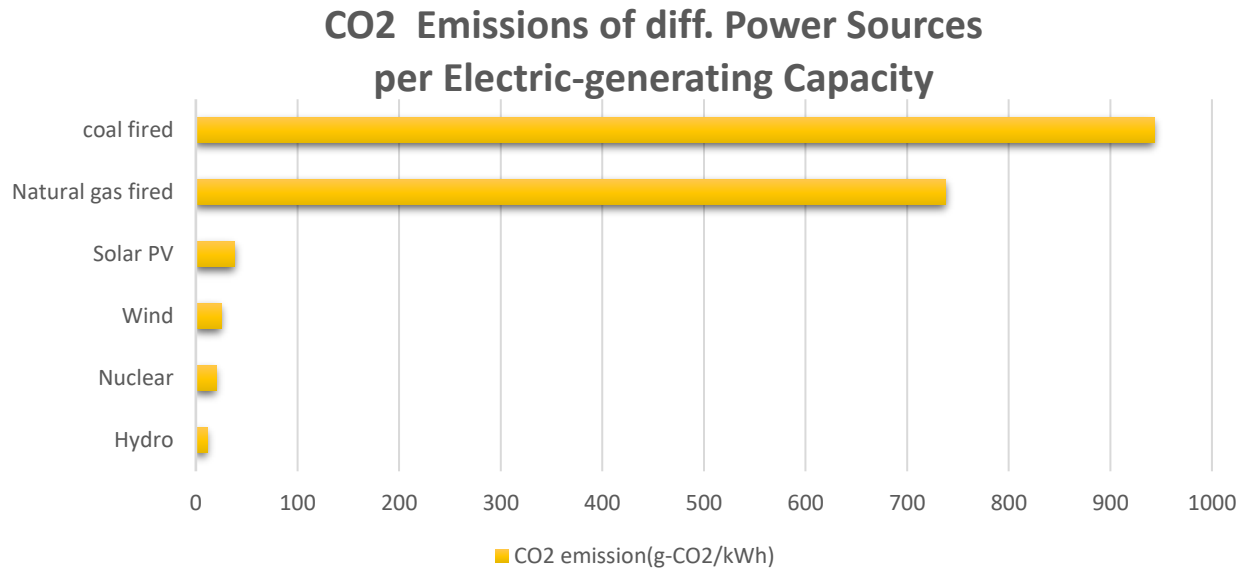
Lightning Rods :- The wind turbine system is protected from lighting by these rods going from the tip of the blade to the ground.

Temporary Rope System :- This system provides temporary fall protection during construction, maintenance or inspection of wind turbine.

ADVANTAGE

- Good for environment as it uses renewable source of energy as wind.
- Wind is freely available in nature.
- Can be setup in remote areas where electricity through transmission wire cannot be reached.
- Clean source of energy as it does not produce any green house gases or any other pollutants.
- Once setup is completed the cost of generation electricity become less.
- Can be combined with solar electricity to give reliable supply of electricity.

Cost comparison of different sources		
Power plant type	**Cost ($/kW-hr)**	**Renewable sources**
Natural gas	0.07-0.13	No
Hydro	0.08	Yes
Coal	0.08-0.14	No
Wind	***0.08-0.15***	***Yes***
Nuclear	0.10	No
Biomass	0.10	Yes
Solar PV	0.13	Yes



DISADVANTAGE

- Site Specific i.e suited to particular region.
- Create a lot of Noise Disturbances
- Prediction of wind is difficult i.e wind speed varies.
- Threat to wild life as it kills birds.
- Cause visual impact.
- High Initial cost.
- Large requirement of land for wind farm.
- Turbines Interfere With the Reception of Televisions and communication signals.

Future

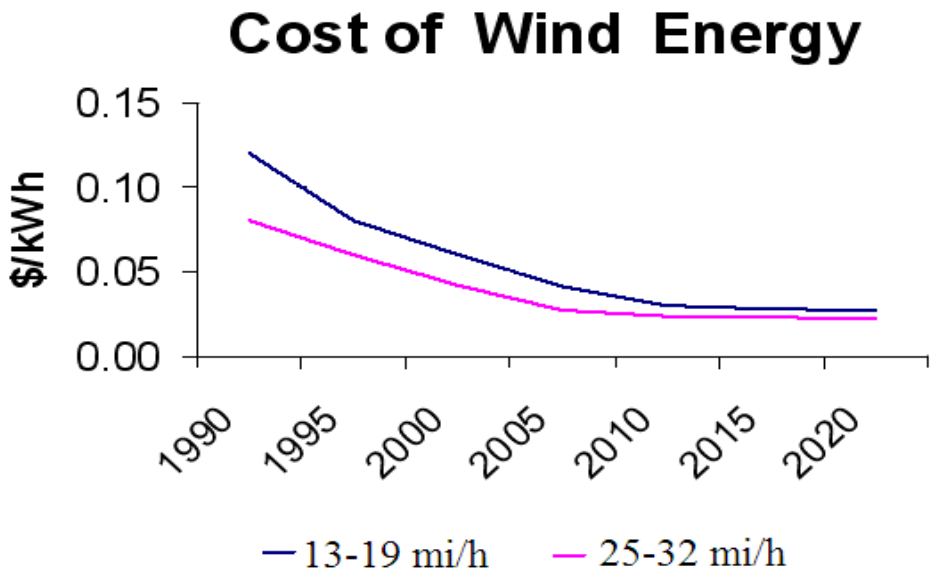
- Wind farms can provide a surplus of reliable clean energy to society.

  Wind alone can not solve today's energy crisis in one day, but together with many other forms of renewable power, maybe someday we can help relieve the damage to our planet caused by the overconsumption of fossil fuels.

- Price of wind power is coming down.

  Technological Developments as application specific Turbines

  - Offshore
  - Limited land/resource areas
  - Transportation or construction limitations
  - Low wind resource
  - Cold climates



- Can become cost competitive for electricity generation if fossil energy costs skyrocket.