Wind Energy: Overview

Learning objectives:

1) To understand the pattern of usage of wind energy internationally
2) To understand the pattern of usage of wind energy in India
3) To become aware of geographical issues associated with wind energy
4) To become aware of different types of windmills

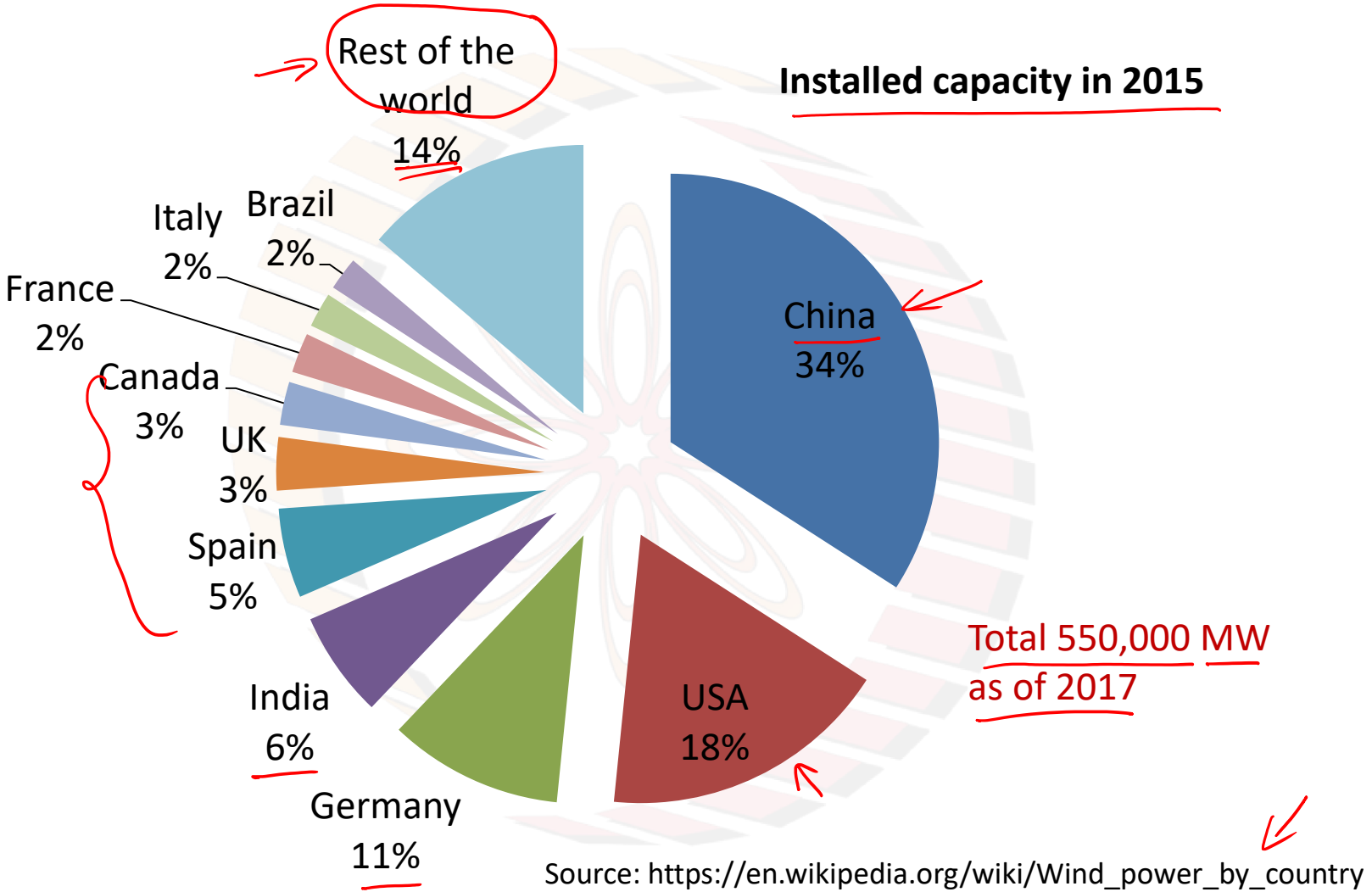
Historical usage of windmills

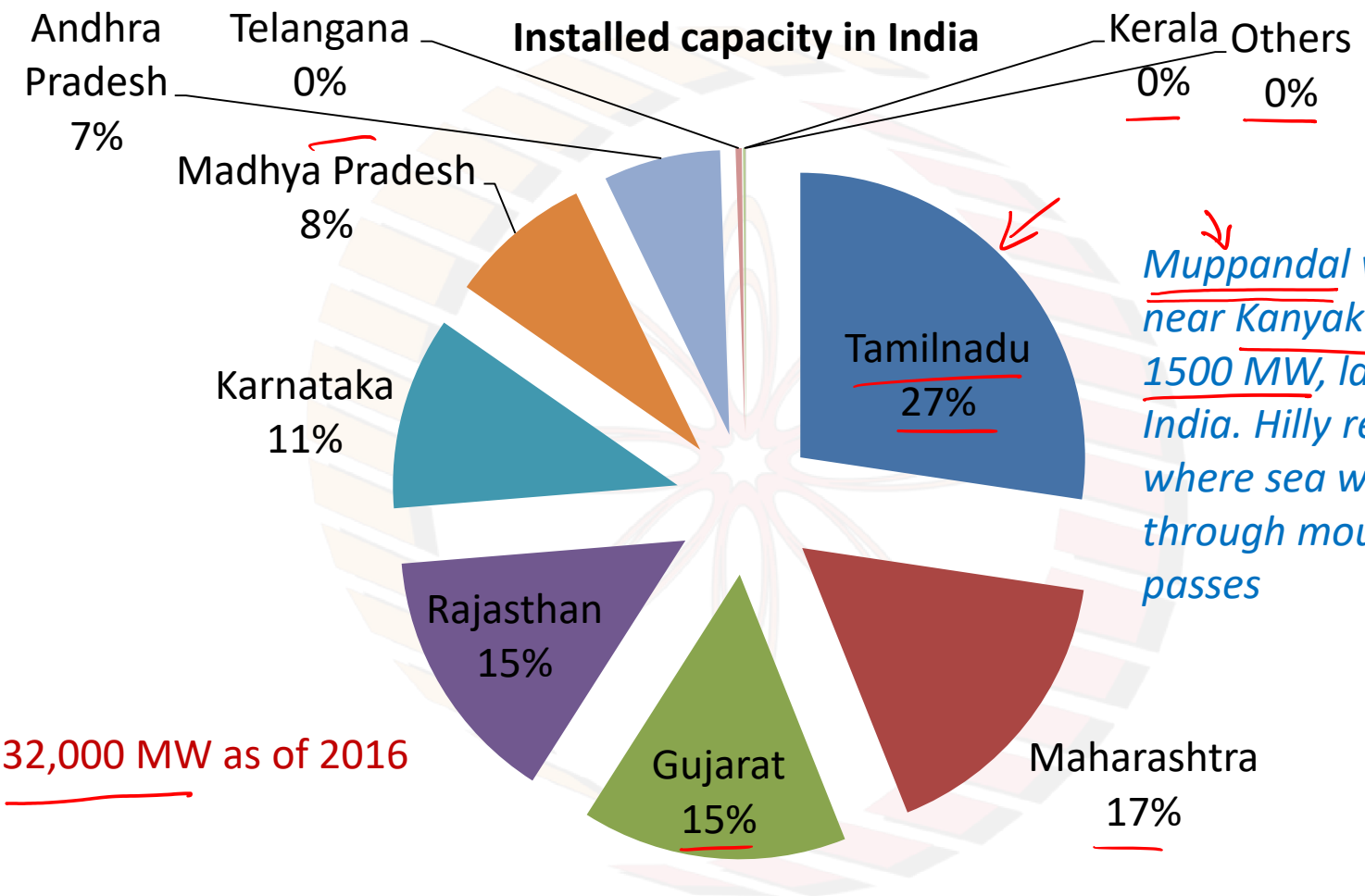
Wind turbine

1)Grinding grains
2)Pumping water
3)Generating electricity

Requirements

1)At least 16 km/h winds
2)Low likelihood of bursts of wind
3)Access to transmission capacity

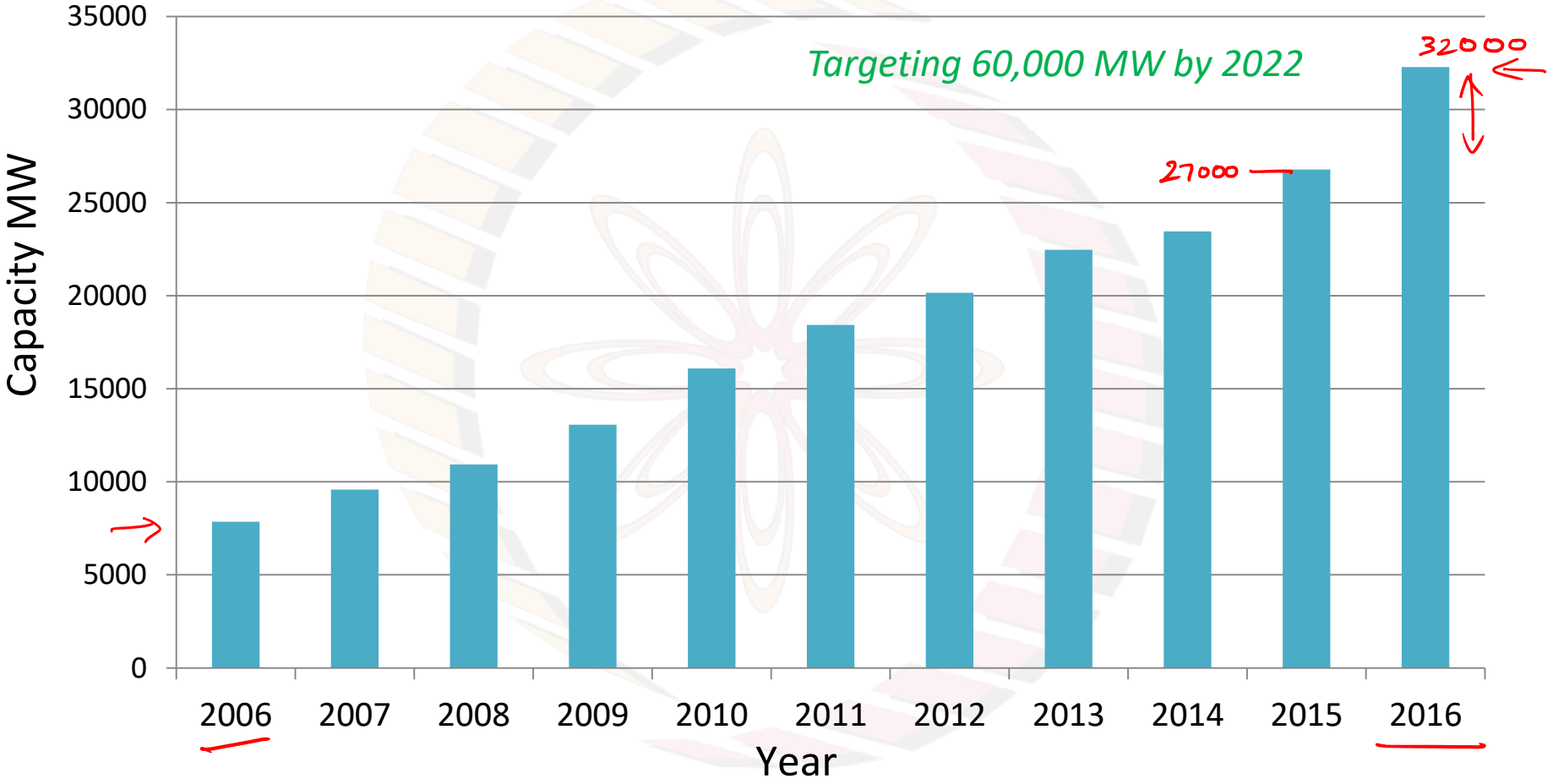

Installed capacity in 2015
Rest of the world 14%
China 34%
USA 18%
Germany 11%
India 6%
Spain 5%
UK 3%
Canada 3%
France 2%
Italy 2%
Brazil 2%
Total 550,000 MW as of 2017
Source: https://en.wikipedia.org/wiki/Wind_power_by_country



Muppandal windfarm, near Kanyakumari, 1500 MW, largest in India. Hilly region where sea winds go through mountain passes

Total 32,000 MW as of 2016

Source: https://en.wikipedia.org/wiki/Wind_power_in_India

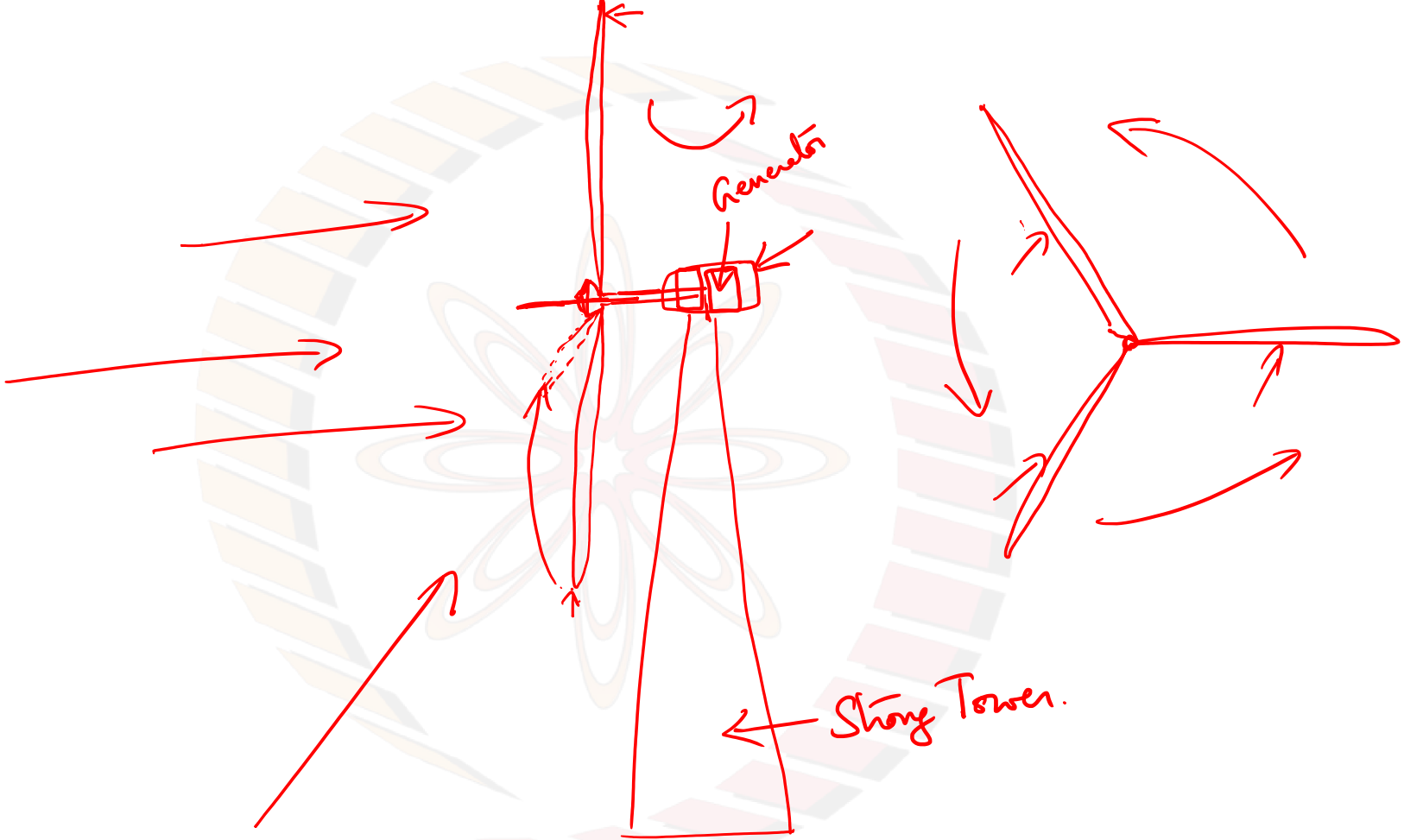


Source: https://en.wikipedia.org/wiki/Wind_power_in_India

Types of windmills

1) Horizontal axis wind turbines
    a. Tall towers enable accessing stronger winds
    b. Blades capture wind energy throughout rotation

    a. Strong and huge towers required
    b. Complexity during construction
    c. Need to be turned to face the wind

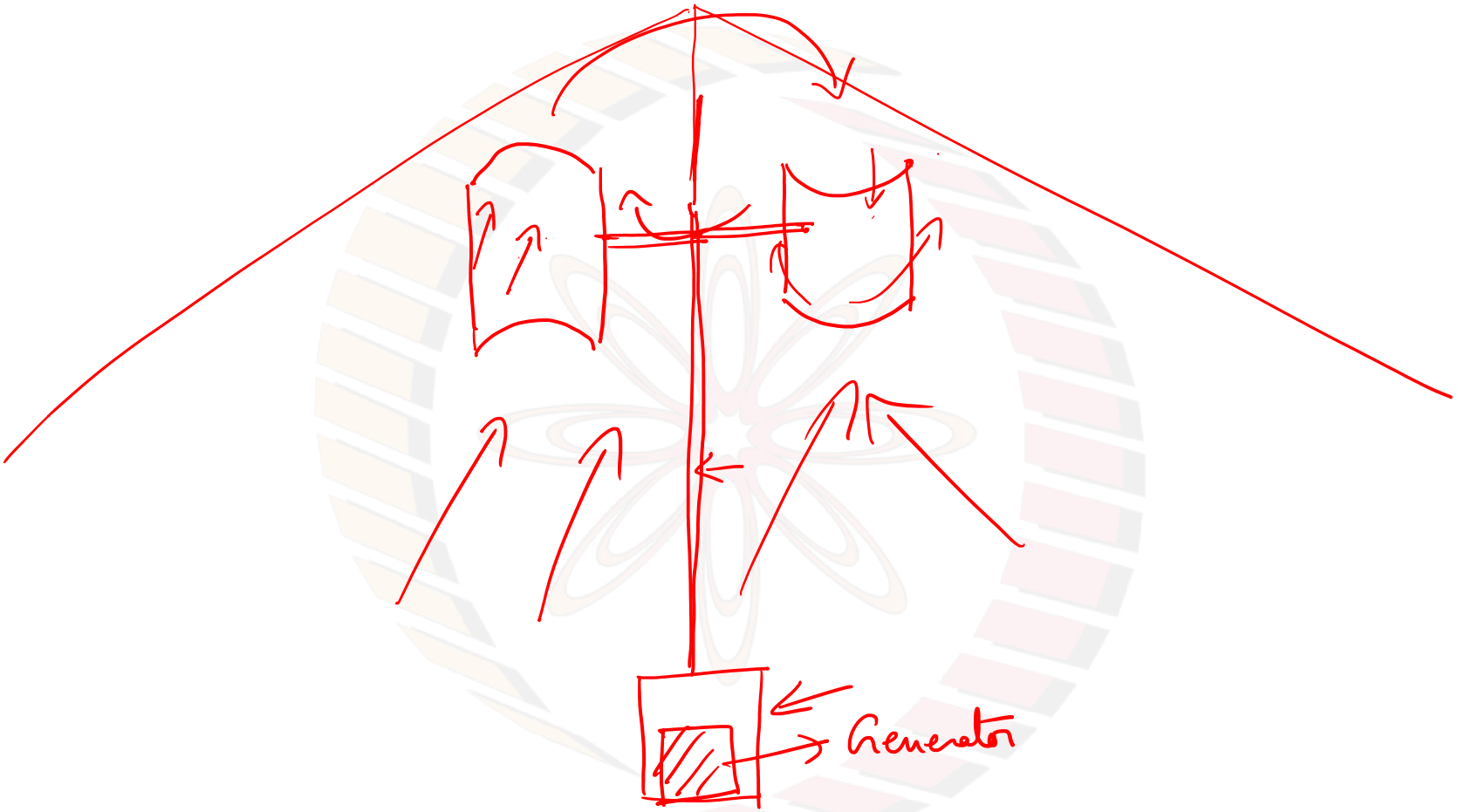

Generator
Strong Tower.

Types of windmills

2) Vertical axis wind turbines

a. Generates power independent of wind direction
b. Low cost
c. Strong tower not needed since generator is on the ground

a. Low efficiency (only one blade works at a time)
b. May need wires to support
c. More turbulent flow near ground


Generator

Power generated:

Large wind turbine: 2-3 MW

0.25 x 2 MW
0.5 MW

Per year, at 25% capacity factor, it will generate:

$$2 \times 10^6 \times 0.25 \times 3600 \times 24 \times 365 = 1.6 \times 10^{13}\ J$$

Therefore, 500 exa joules will require:

$$500 \times 10^{18} / 1.6 \times 10^{13} = 31 \times 10^6$$

31 million Turbines

31 Million wind turbines

Space requirement:

Rule of thumb is 7 times diameter of windmill

2000 kW
500 kW

Approximately 500 m from other turbines

→ 2-5 kW
100 Houses
200 Houses.

Each 2 MW turbine needs approximately 0.5 square km

Therefore 15.5 million square km needed to power the world!

1.5 times Size of China or USA

Conclusions:

1) Considerable interest in tapping wind energy both internationally as well as in India
2) Geographical locations play an important role in planning windmill installations
3) Various designs of wind mills considered historically