Wind Energy Fundamentals

Ahmed Hammam

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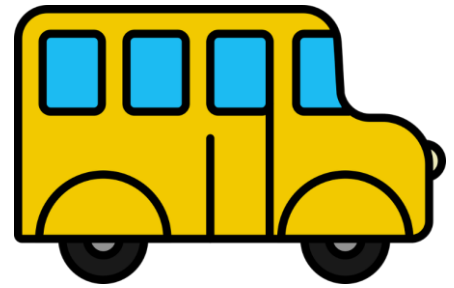
Agenda

- Energy and Wind
- Wind Energy History
- Wind Resources and Characteristics
- Wind Measurement & Atlas
- Wind Turbines
- Wind Farm Development

What is Energy??

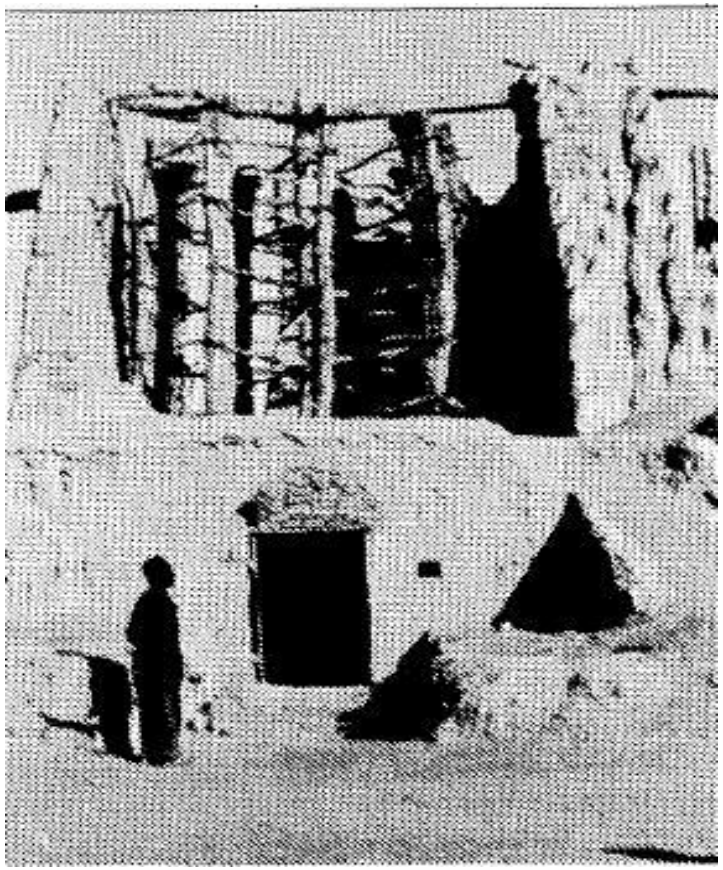


Wind ?

- Wind Energy is one of the oldest energy sources used
- Wind Energy is an indirect form of Solar Energy
- Air movement due to difference in Atmosphere Temperature and pressure
- Wind is the movement of Air in the Atmosphere, horizontally and vertically
- Horizontal movement speed is 100-1000 times to that of Vertical movement

The Wind

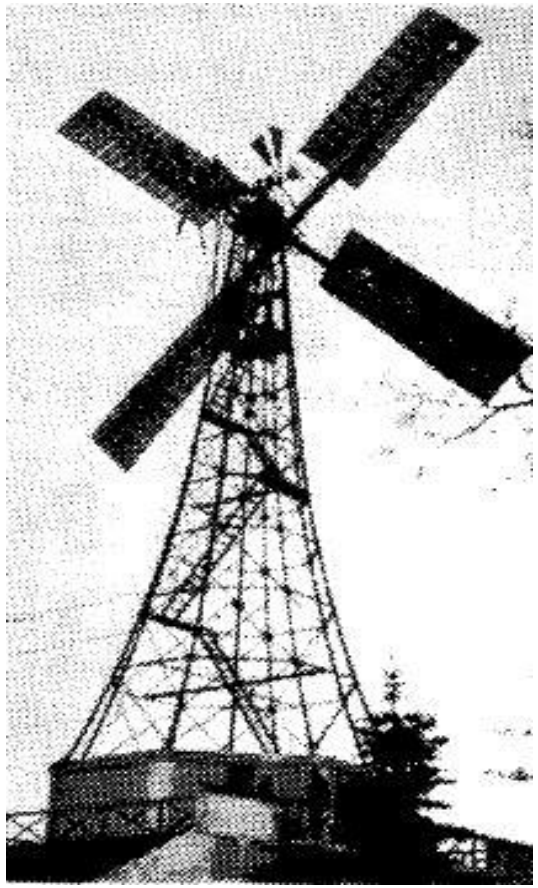
History



- >3000 years used by Ancient Egyptians
- First recorded windmill returns to 945 BC in Persia
- The windmill idea transferred to Europe during the middle ages for mechanical usage

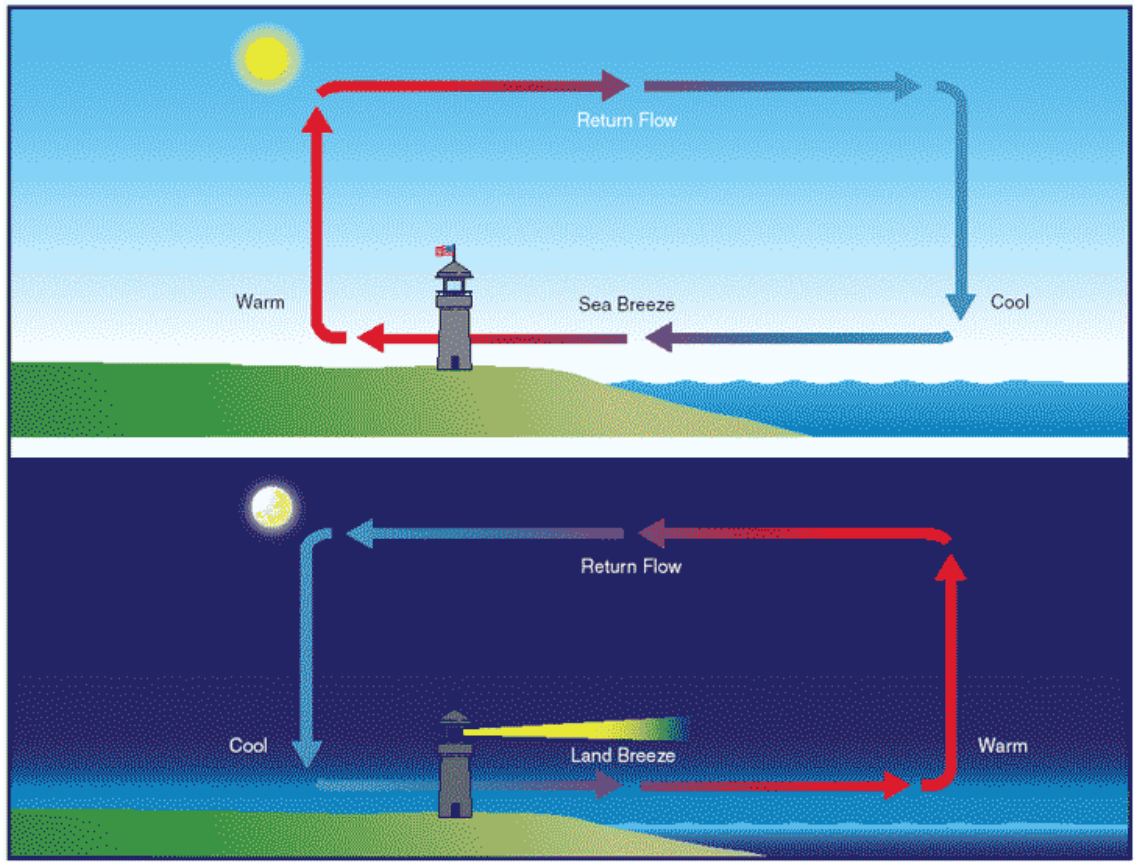
History

- 1700&1800 development of wind turbines in Holland, Denmark
- Late 19th century, First Electrical wind turbine 12 KW
- Paul la Cour developed and build over 100 20-30 KW turbines in Denmark
- Early 20th Century, Forgotten
- 70’s The Return



Wind Resources

- Difference in Temperature between Equator and poles
- Rotation of Earth (Coriolis Forces)
- Geographic distribution varies in solar energy absorption



Wind Types in Egypt

Permanent

Seasonal

Local

Wind Characteristics

01
Avg. Wind Speed

02
Wind Direction

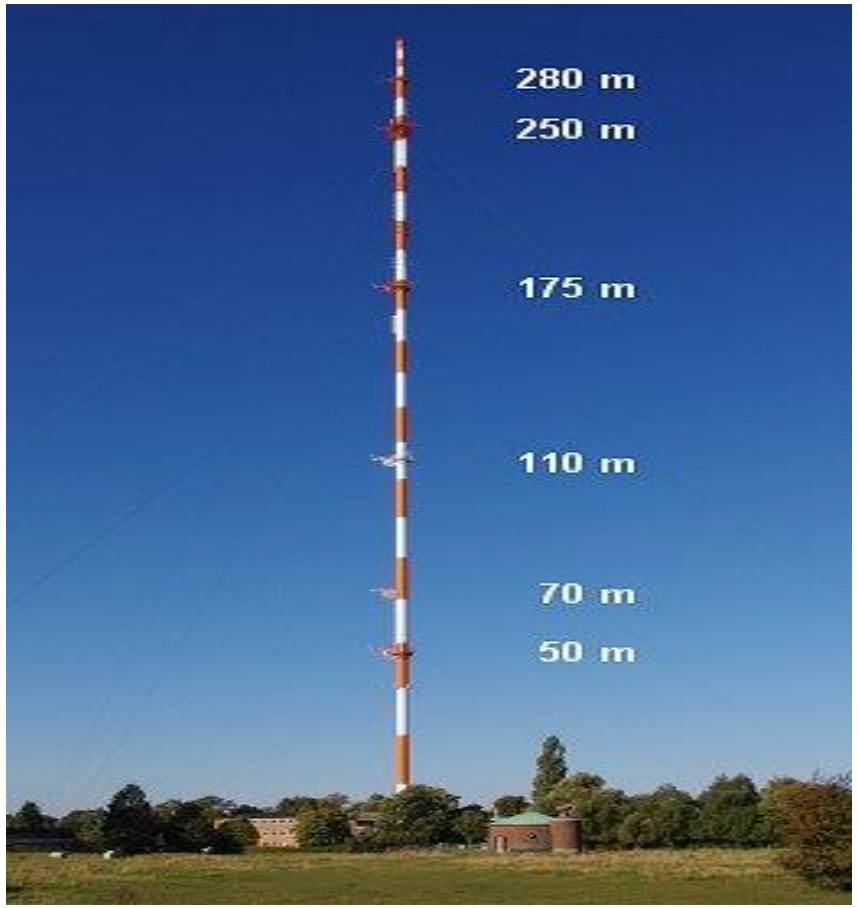
03
Vertical Wind Profile

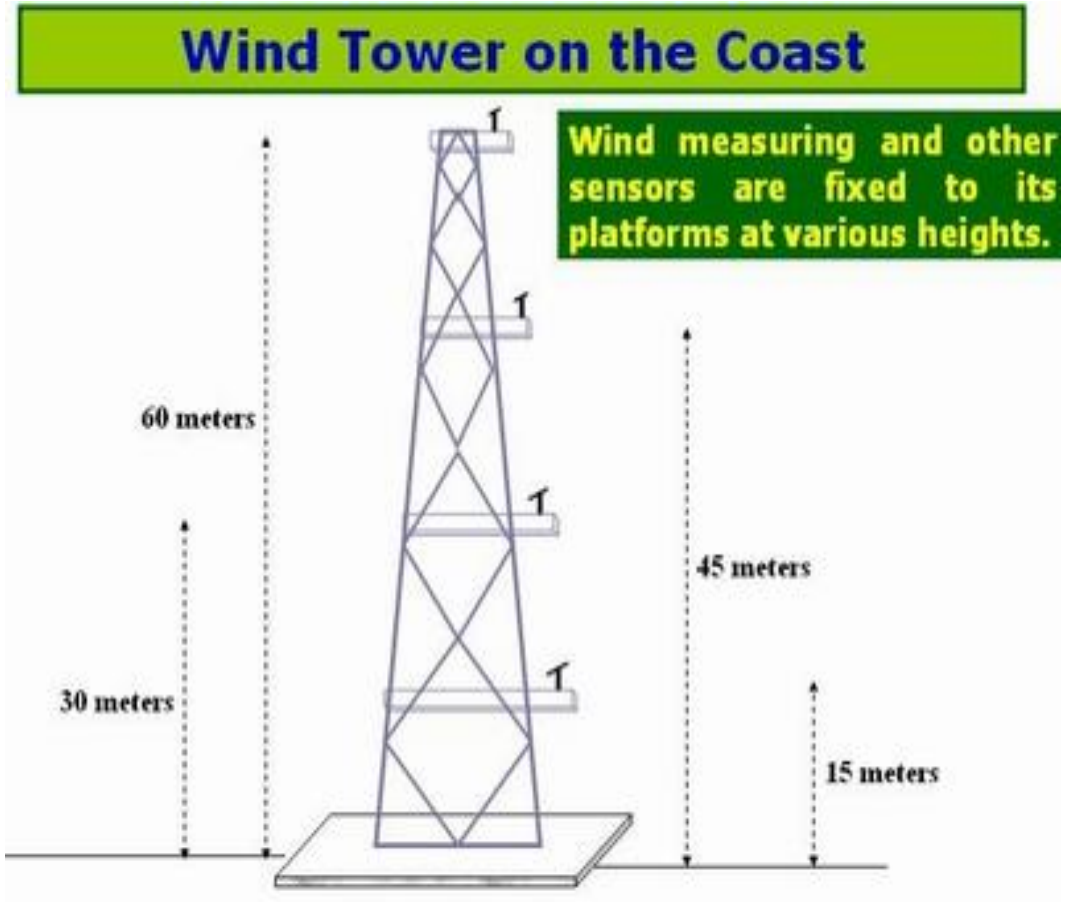
04
Steadiness

05
Turbulence and Gusts

06
Surface Roughness and Topography

Wind Measurements





Wind Measurement Instruments

- Anemometer

- Wind Vane

- Ultrasonic

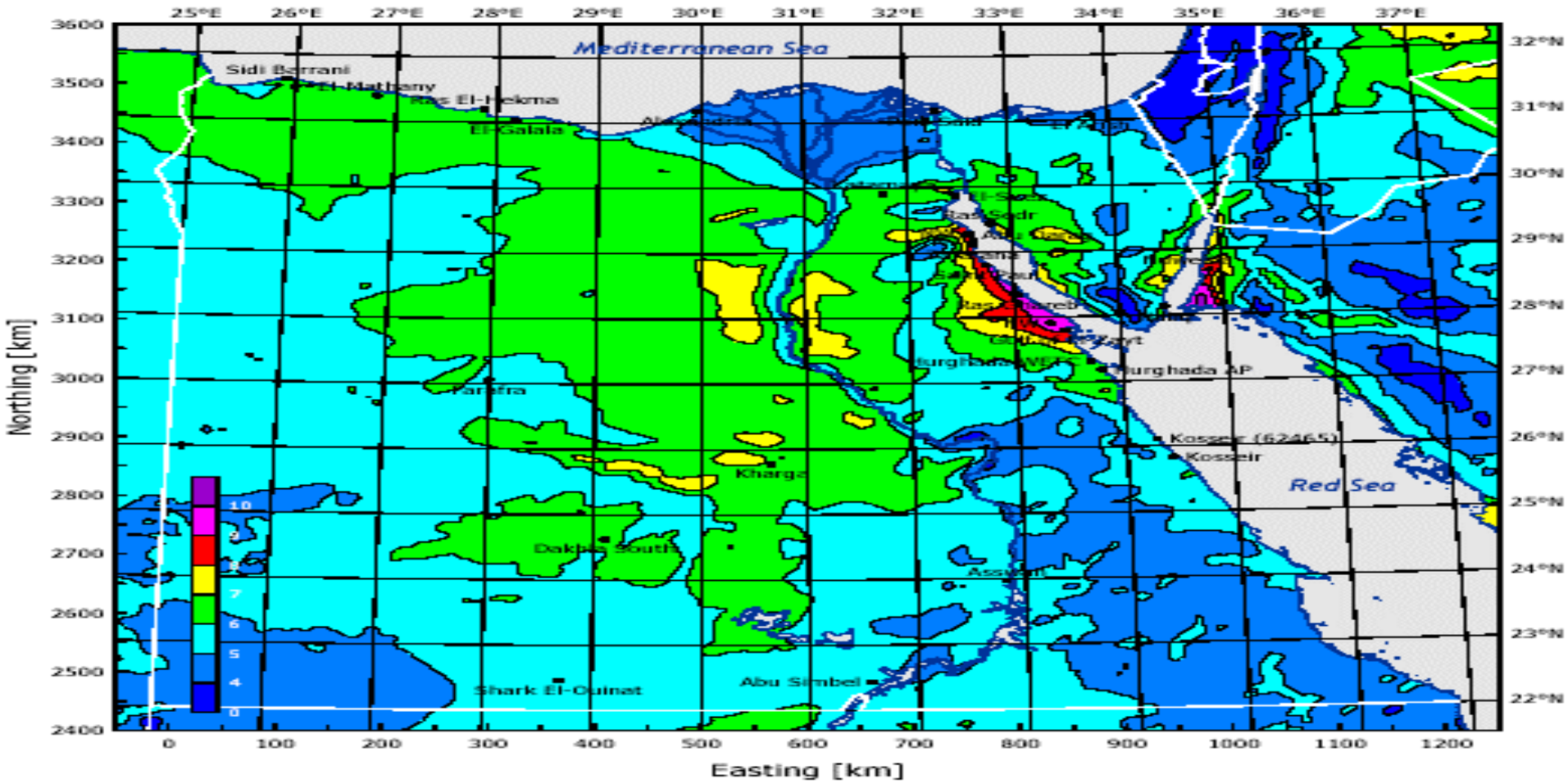
Egypt Wind Atlas

Denmark RISO conducted Wind Measurements in Egypt

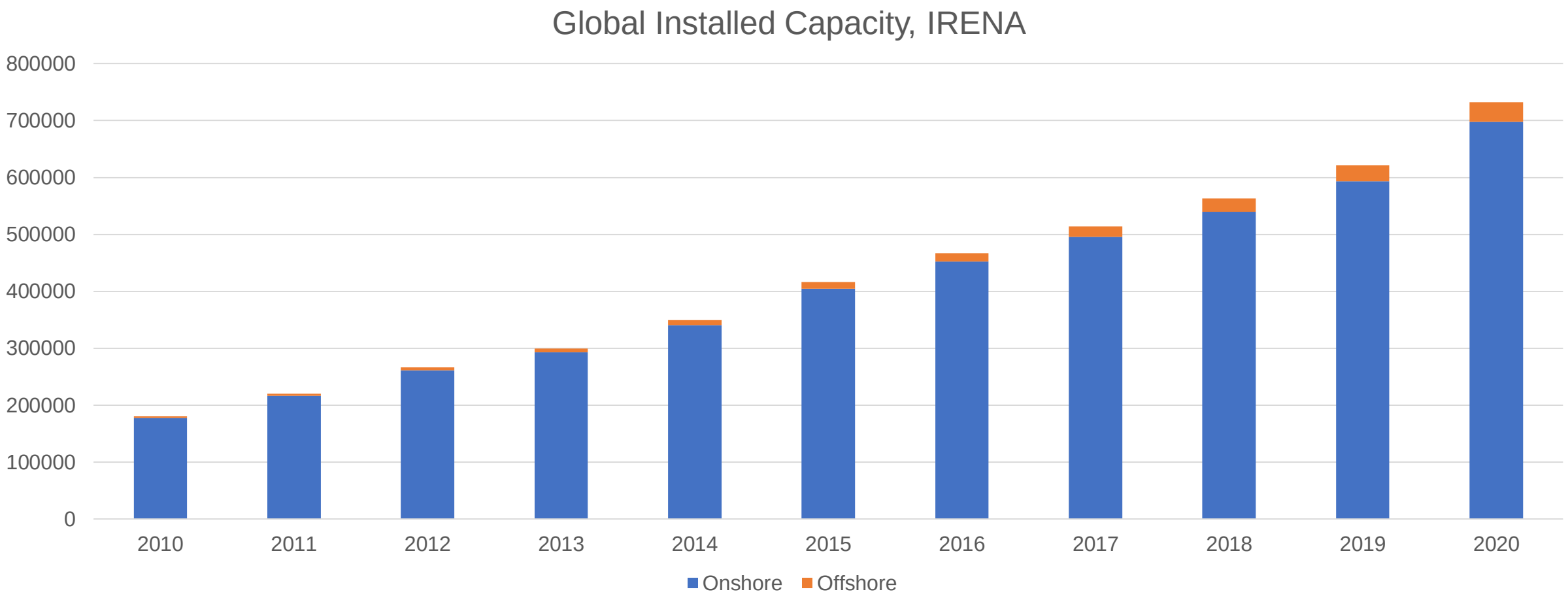
Illustrates wind speeds in various geographical locations

The Atlas provides wind speed, regime and characteristics

Wind Atlas


Mediterranean Sea
Red Sea
Sidi Barrani
El-Galala
Farafra
Kharga
Dakhla South
Shark El-Ouinat
Abu Simbel
Hurghada AP
Kosseir
Northing [km]
Easting [km]
25°E
26°E
27°E
28°E
29°E
30°E
31°E
32°E
33°E
34°E
35°E
36°E
37°E
32°N
31°N
30°N
29°N
28°N
27°N
26°N
25°N
24°N
23°N
22°N
3600
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
2400
0
100
200
300
400
500
600
700
800
900
1000
1100
1200

Global Wind Energy Trends



Wind & Wind Turbine

- Pwind proportional to v^3 ($Pwind = 0.5\ \rho A v^3$)

- Betz Law calculated the maximum Power extracted from Wind Power

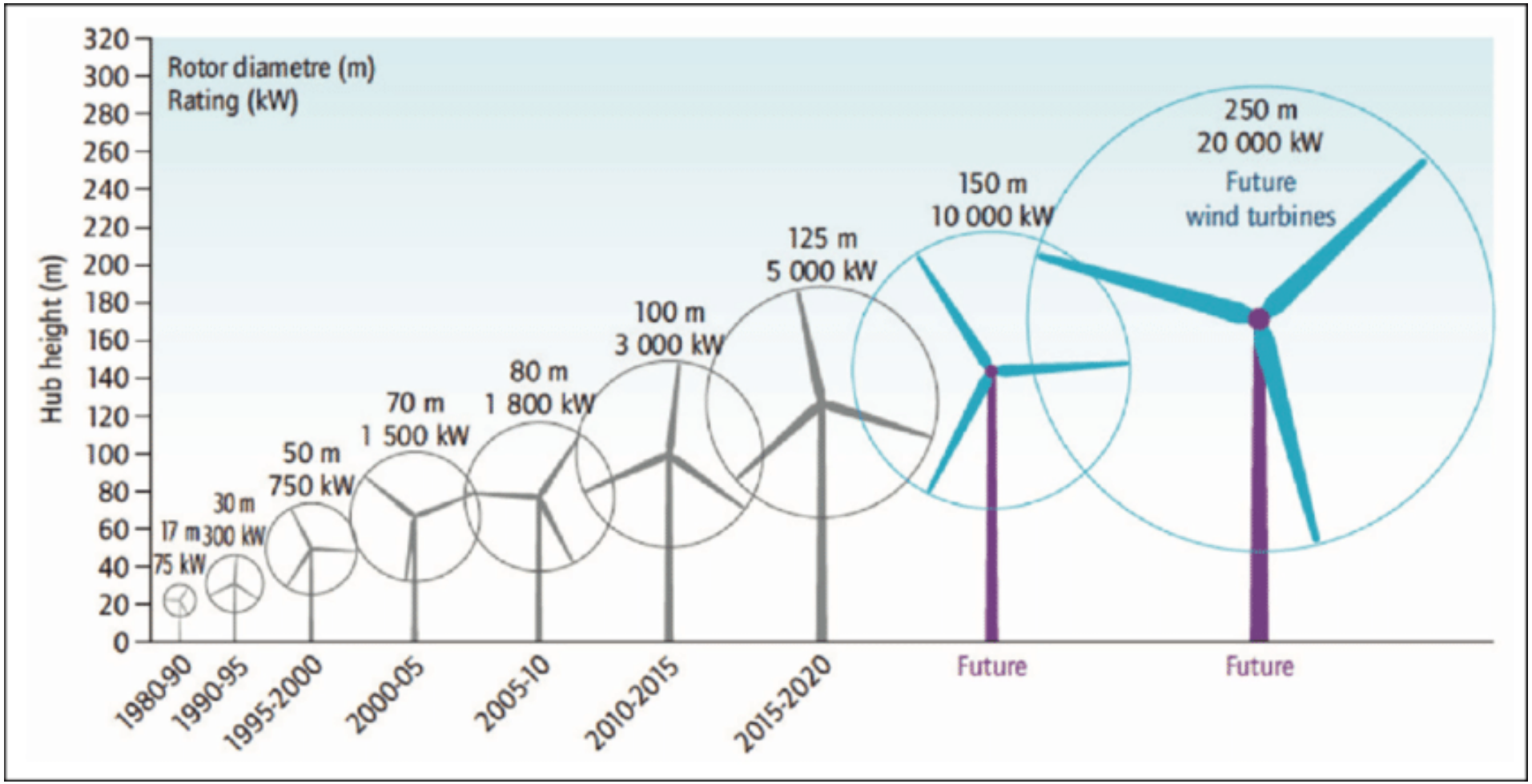
$$C_{p,max} = \frac{P_{max}}{P_{wind}} = \frac{\frac{16}{27} \cdot \frac{1}{2} \cdot \rho . S . v_1^3}{\frac{1}{2}\ \rho . S . v_1^3} = \frac{16}{27}$$

$$= 0.593$$

What's a Wind Turbine

- Electromechanical Machine
- Rotor transfers Kinetic Energy to Mechanical Power
- Mechanical Power transferred to Electrical Energy through Generator

Wind Turbine Evolution



IEA, 2013

Latest Wind Turbine Power

Offshore Wind Turbines

- Vestas V236-15 MW offshore
  - Blade 115 m
  - 15 MW power
- Siemens Gamesa SG14-236
  - 14 MW power offshore
  - Blade 115 m
- GE Haliade-X
  - 14 MW power offshore
  - Blade 107 m

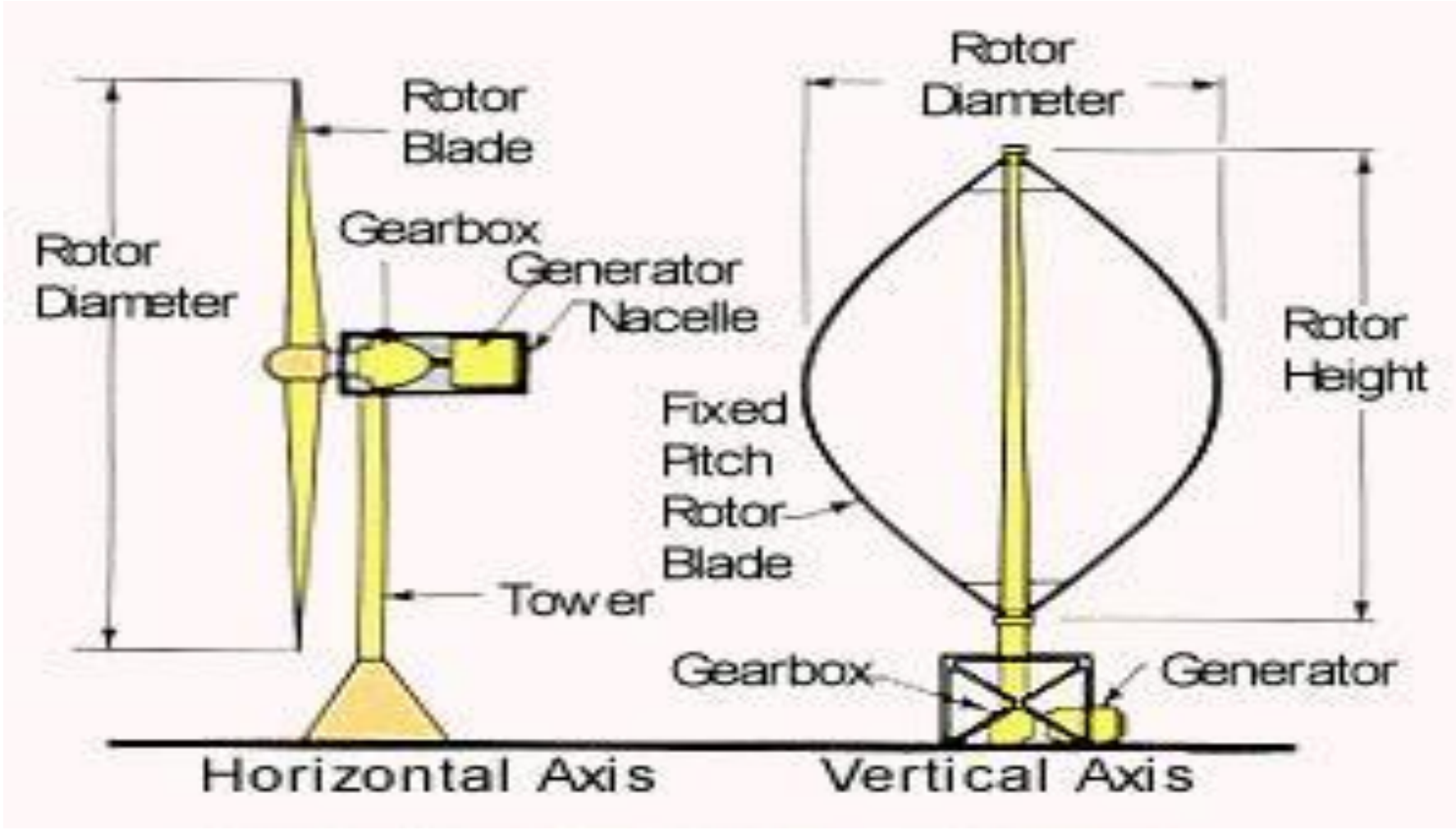
Onshore Wind Turbines

- Enercon E-160
  - 5.5 MW power onshore
  - Hub height 166 m
- GE- 158
  - 6.1 MW power onshore
  - Hub height 161 m
- Nordex N163/6
  - 6 MW power onshore
  - Hub height 164 m

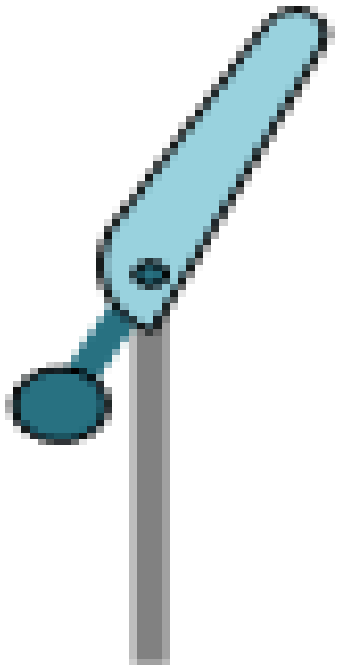
Wind Turbine Configurations

- Horizontal or Vertical Axis
- Number of Blades
- On- or Offshore
- Up- or Downwind
- Variable or Fixed Speed
- Active or Passive Pitch control
- Yaw Control
- Direct Drive or with Gearbox

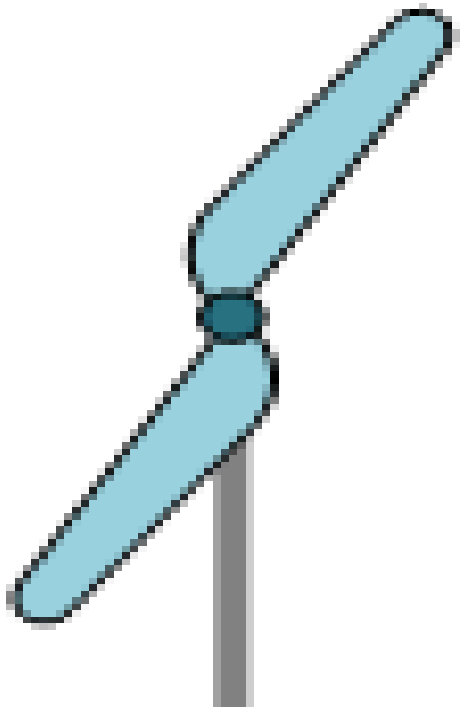
HAWT or VAWT


Rotor
Blade
Rotor
Diameter
Gearbox
Generator
Nacelle
Tower
Horizontal Axis
Rotor
Diameter
Rotor
Height
Fixed
Pitch
Rotor
Blade
Gearbox
Generator
Vertical Axis

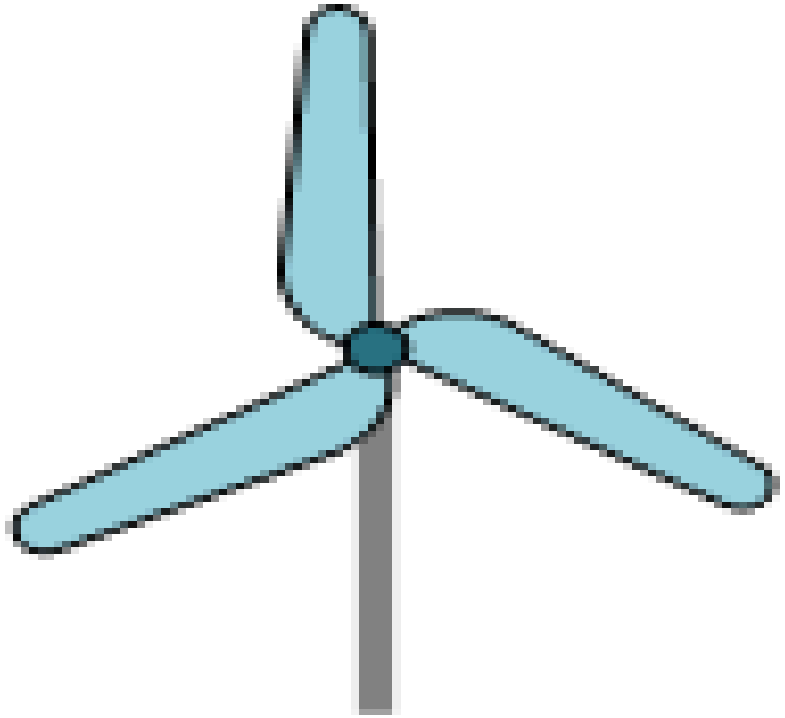
Number of Blades



Single Blade



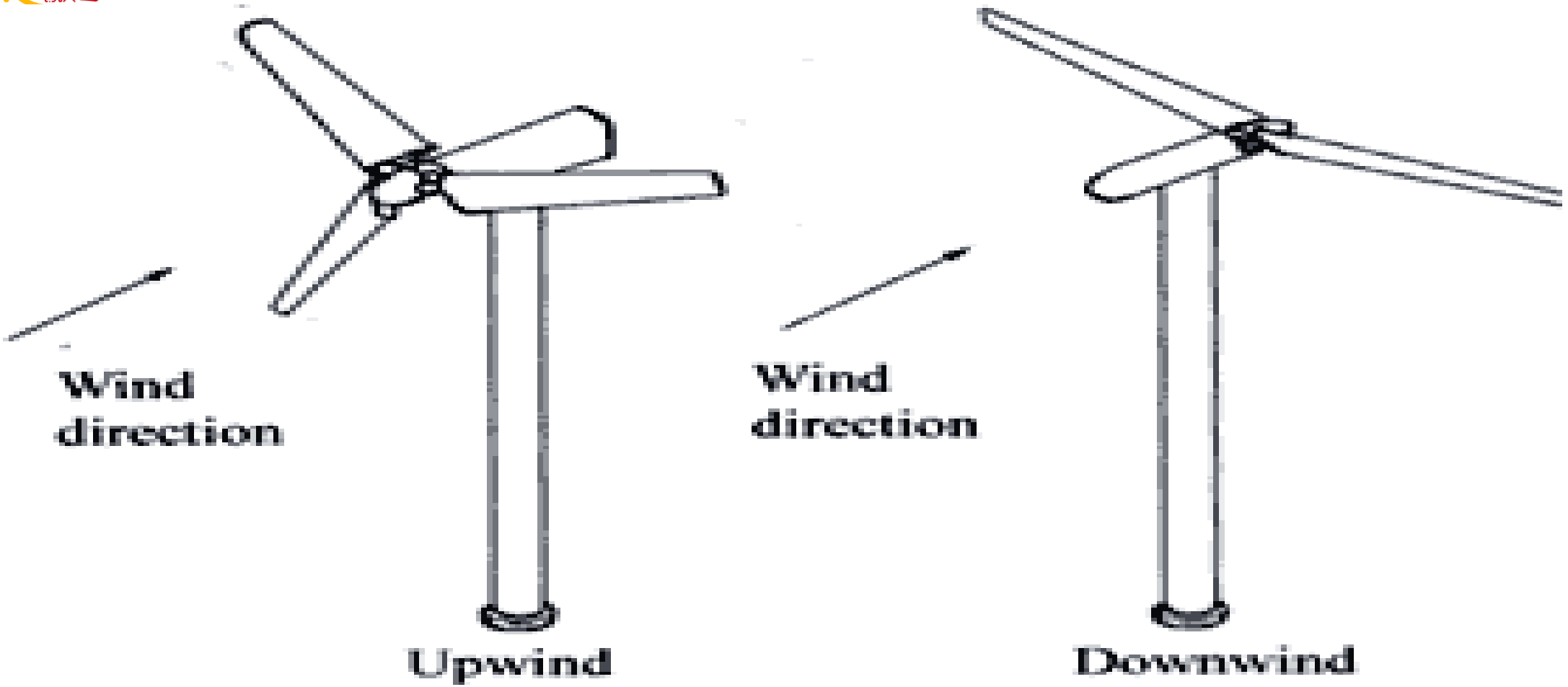
Double Bladed



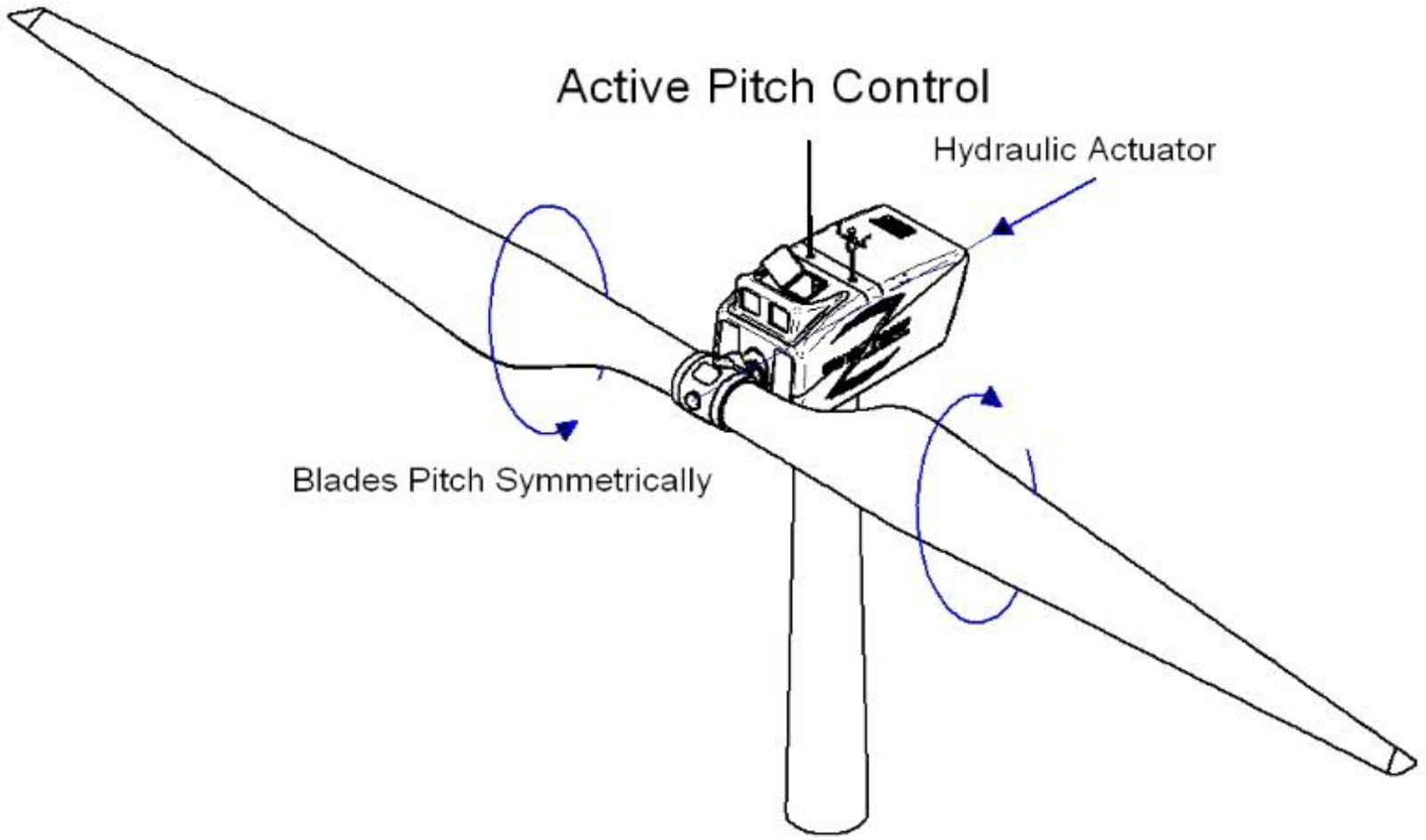
Three Bladed

On- or Offshore

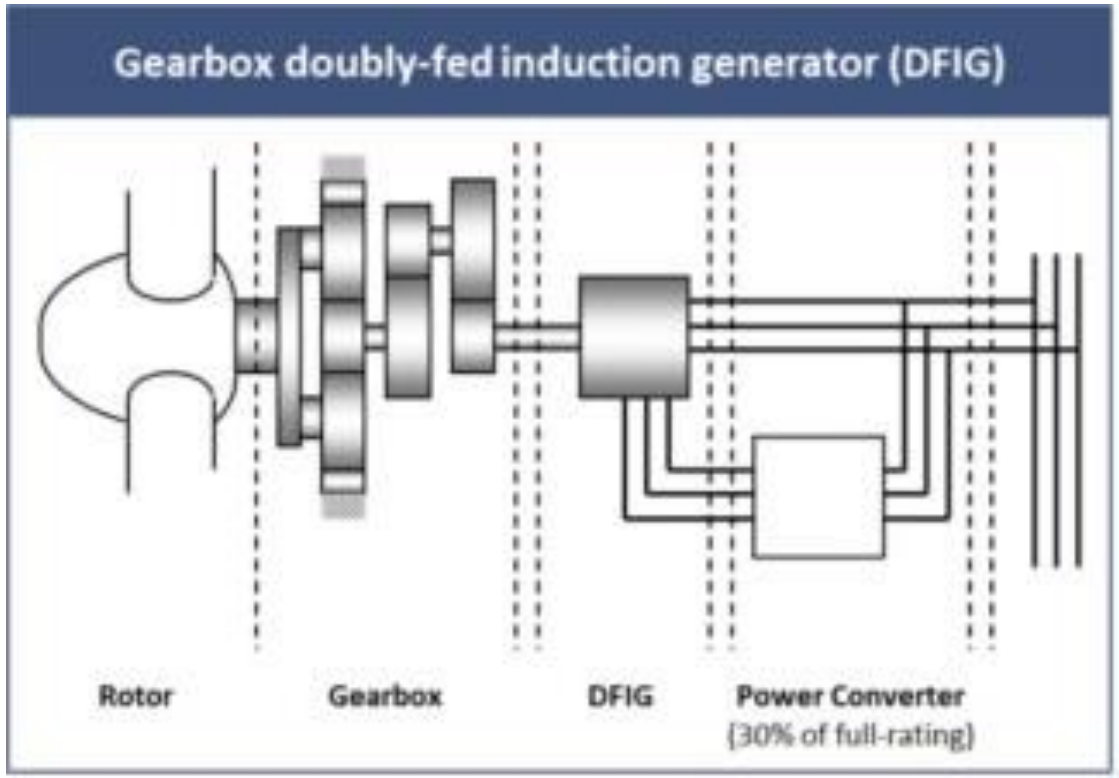
Up- or Downwind

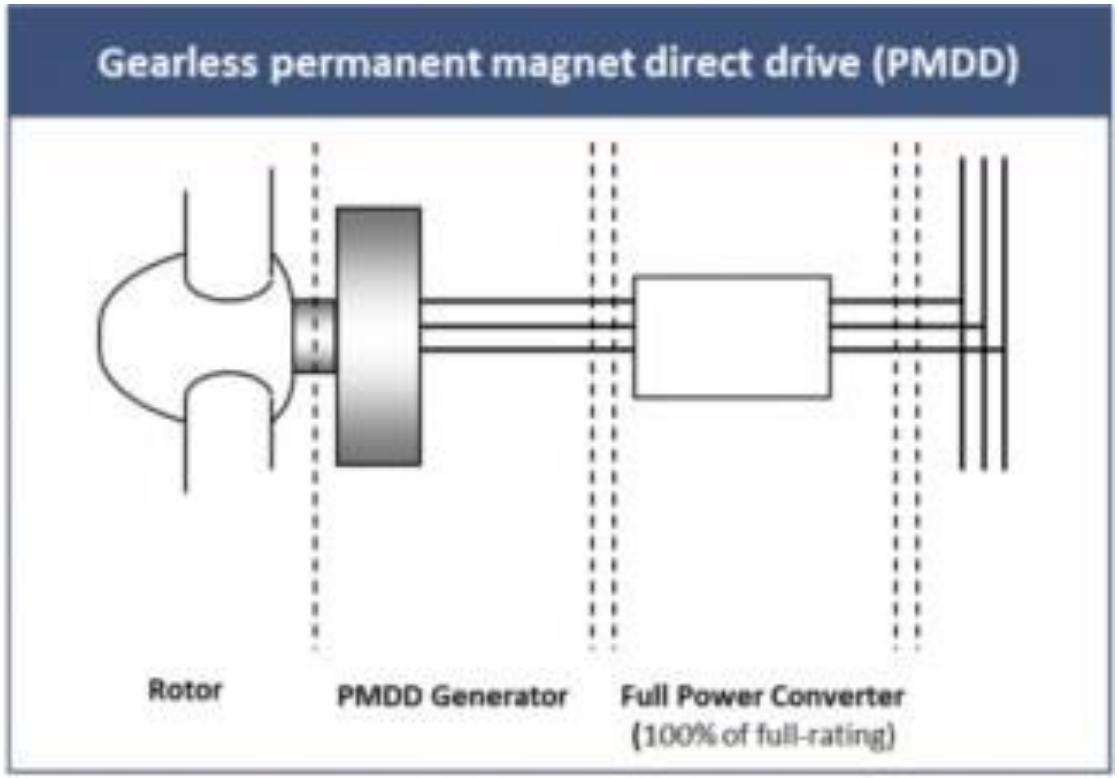


Active or Passive Pitch control



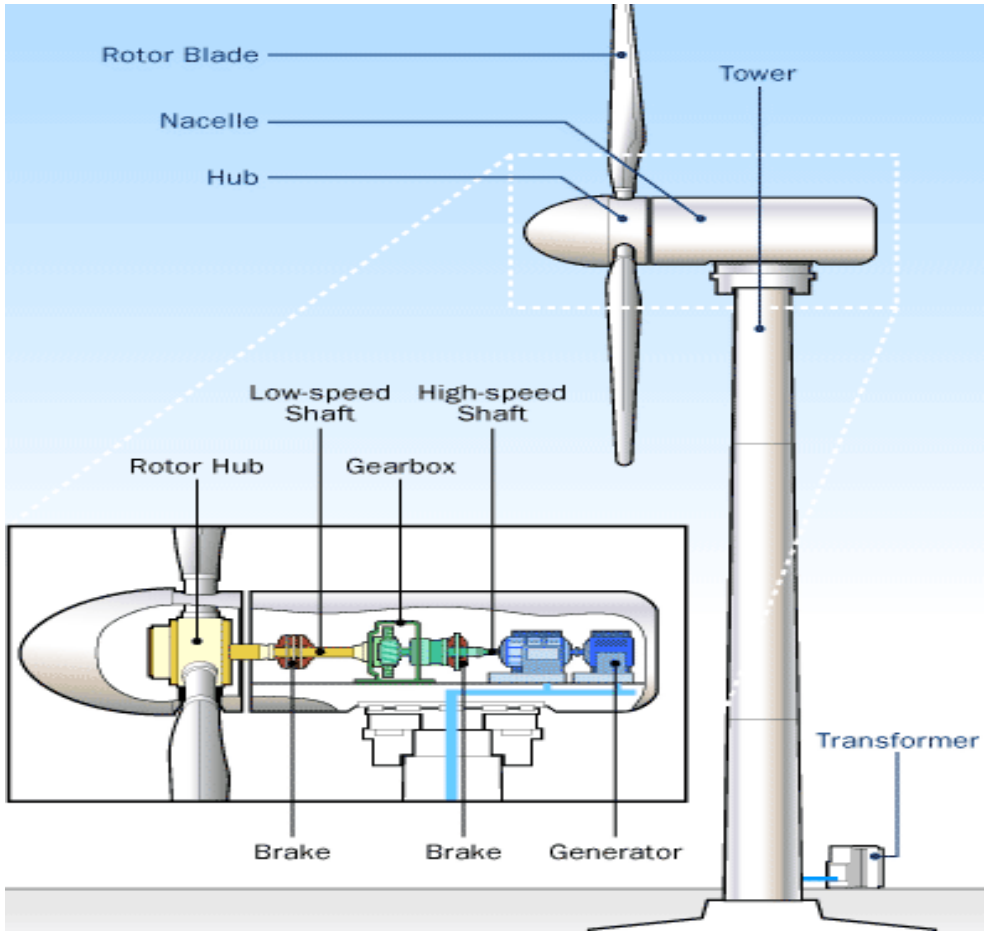
Direct Drive or with Gearbox

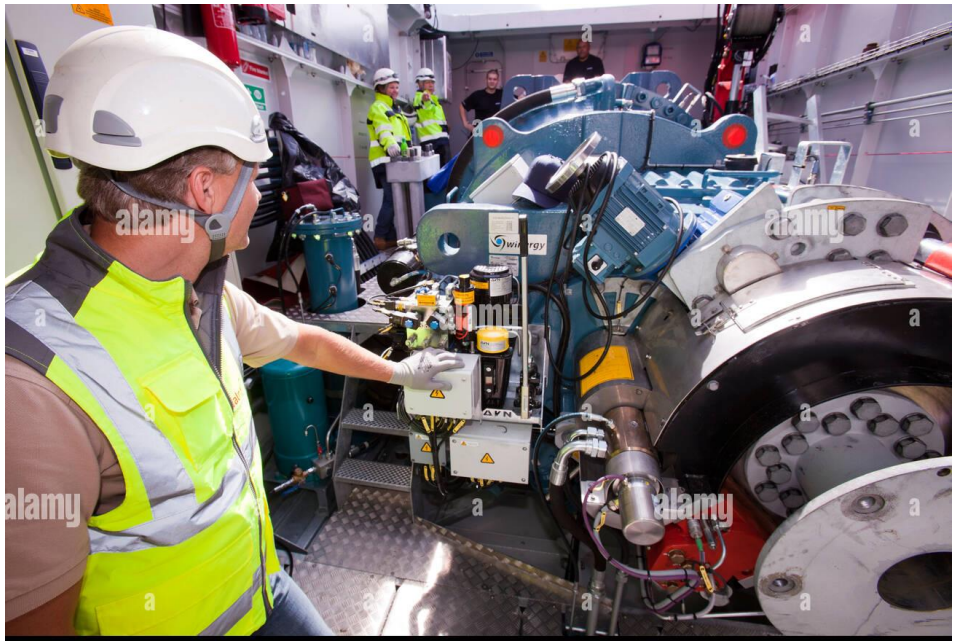




Components

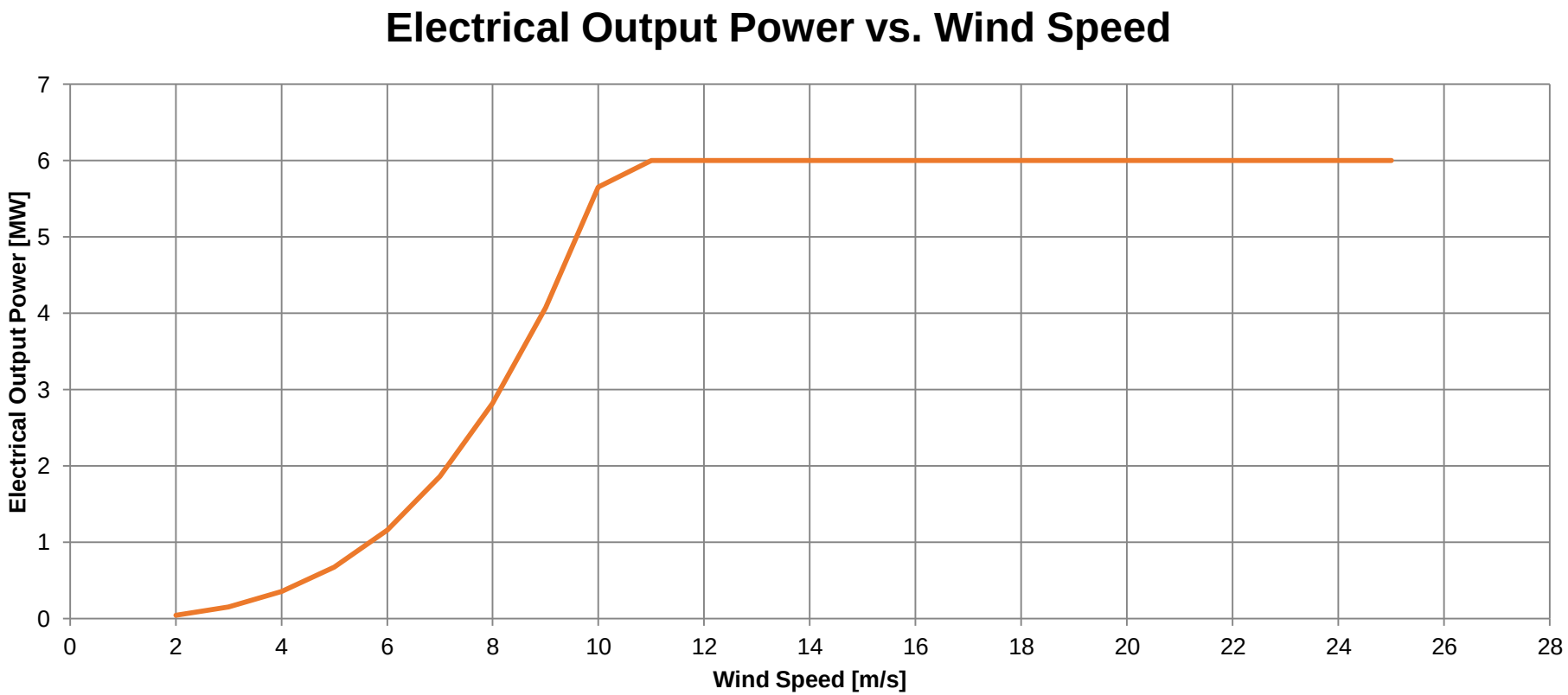
- Rotor Hub
- Blades
- Nacelle
- Tower
- Foundation



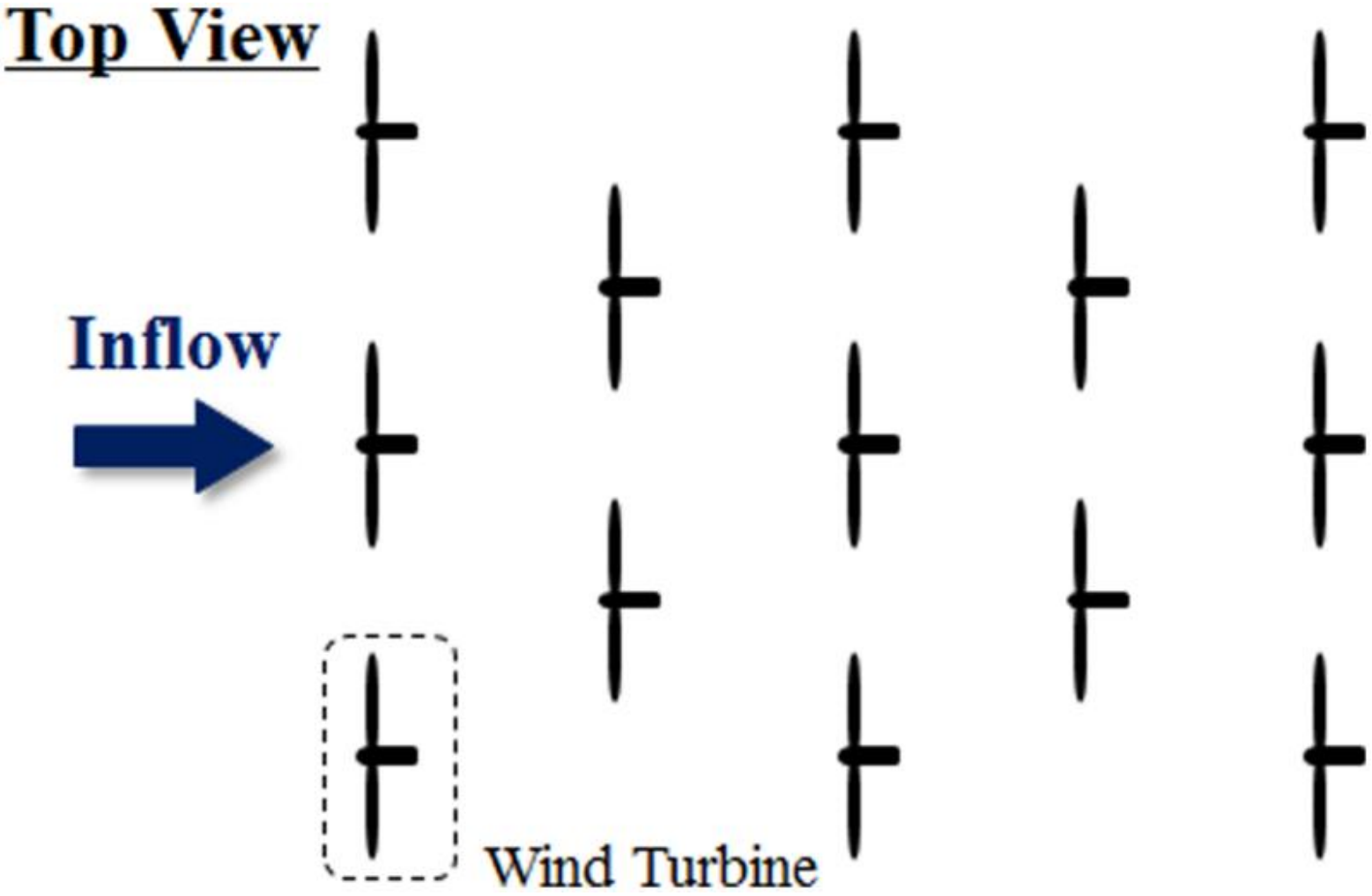



SUZLON

Theory of Operation (Power Curve)

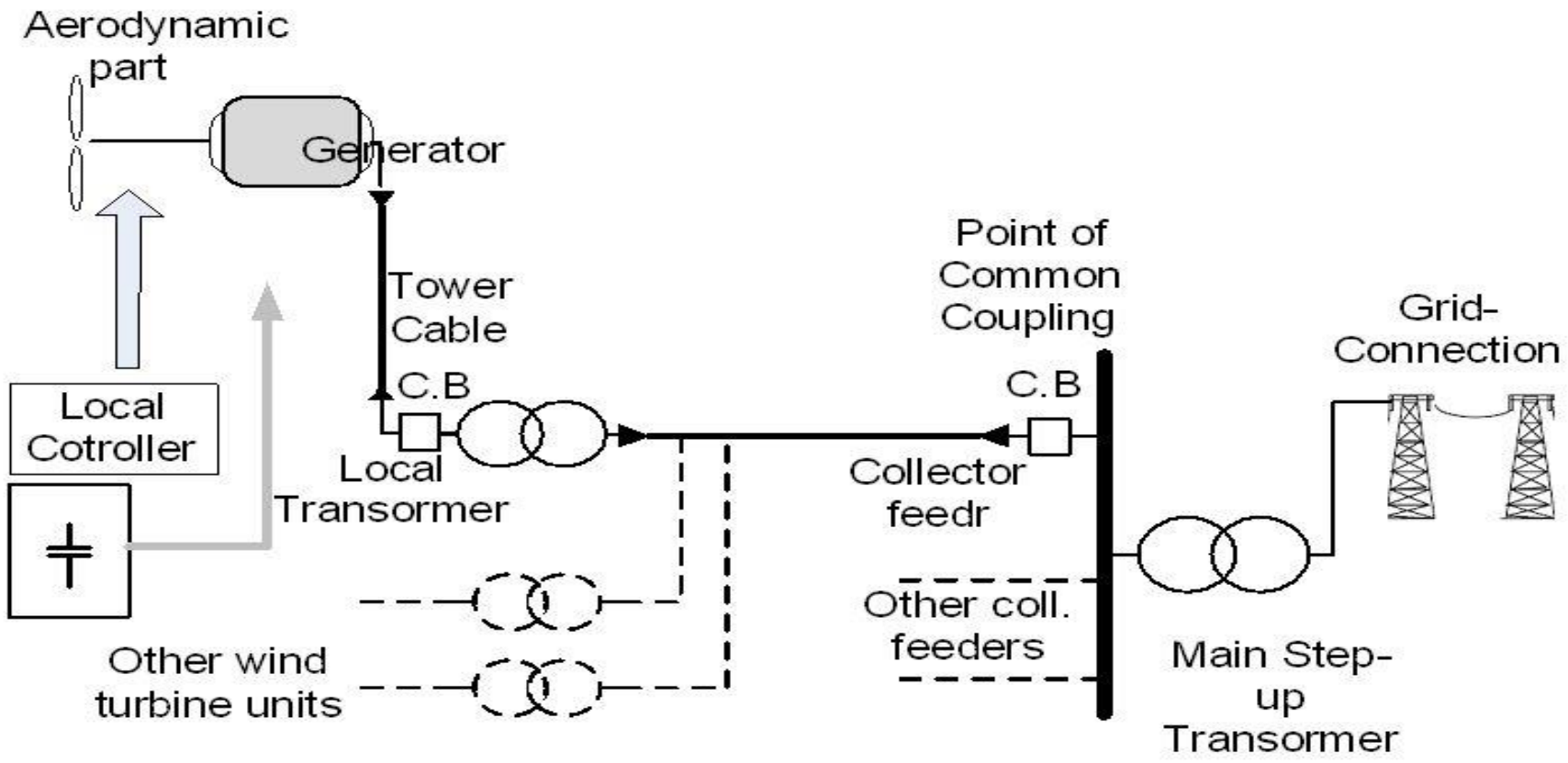


Wind Farms

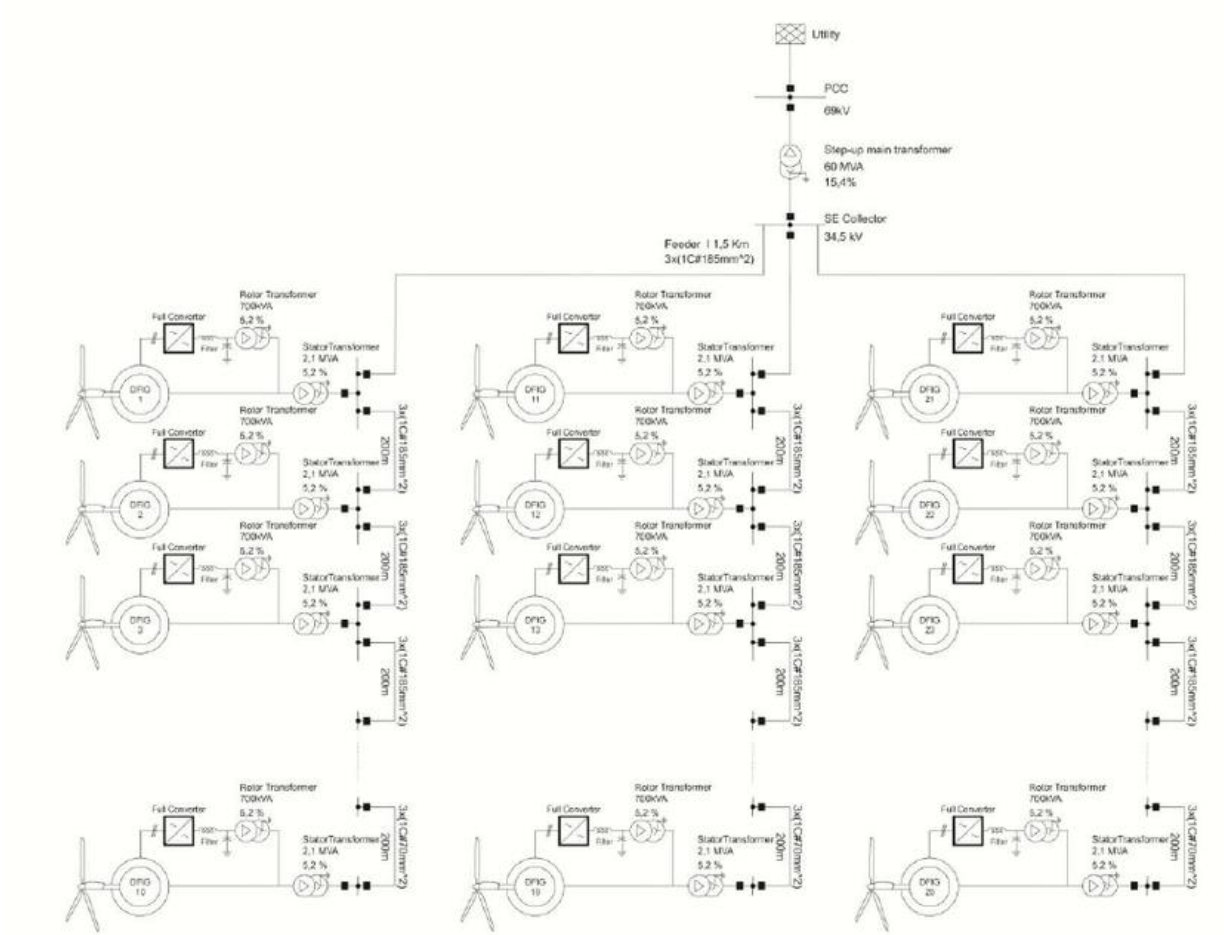


Wind Farm

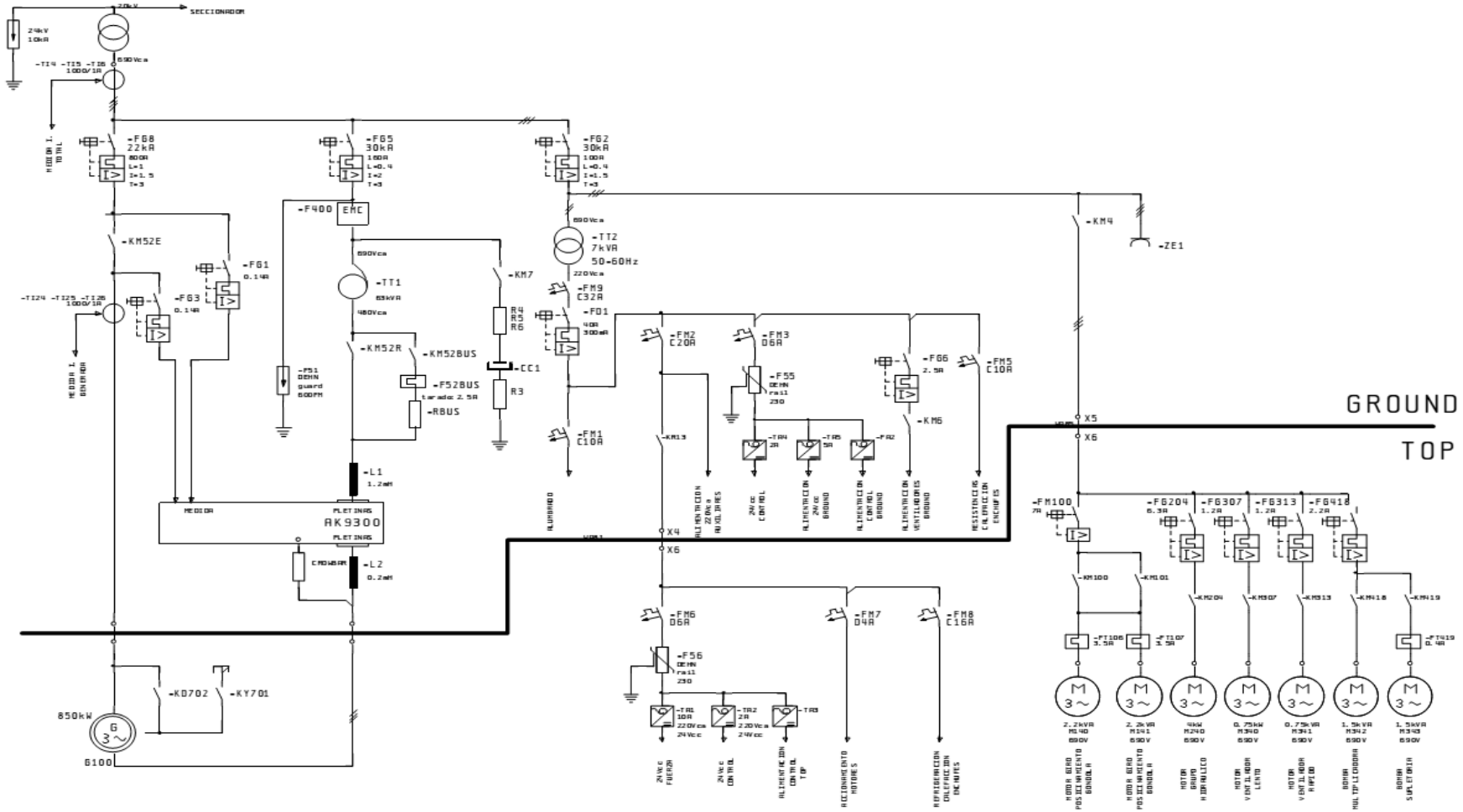
Wind Farm Connection Schematic



Wind Farm SLD



Wind Farm SLD



Wind Project Development

- Government land acquiring (NREA)
- Project Finance
- Agreement finalizing (Competitive Bidding, BOO, PPA, FiT,….)(EETC,NREA)
- Project development & feasibility study
  - Site selection (Land acquiring)
  - Wind analysis & Environmental Study
  - Micro siting
  - Environmental statement
- Construction & Installation
- Validating, testing and commissioning
- Grid connection
- Operation

Environmental Statement

- *Policy framework*
- *Procedures policies*
- *Site selection*
- *Designated areas*
- *Visual and landscape assessment*
- *Noise assessment*
- *Ecological assessment*
- *Archaeological and historical assessment*
- *Hydrological assessment*
- *Interference with telecommunication systems*
- *Aircraft safety and interference with radar*
- *Military*
- *Safety*
- *Traffic management and access construction*
- *Electrical connection*
- *Economic effects on the local economy , global environmental benefits*
- *Decommissioning*
- *Mitigating measures*
- *Non-technical summary*

Wind Turbine Erection

NREL 1.5 MW

Wind Turbine Erection

GE 3.6 MW

Offshore Wind Turbine Erection

Contact

Ahmed Hammam

Ah.g.Hammam@gmail.com

https://www.linkedin.com/in/ahmed-hammam-799674ab/

https://suremap.eu

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