Energi Terbarukan

Pertemuan 9:

PLTB

Dosen Pengampu:

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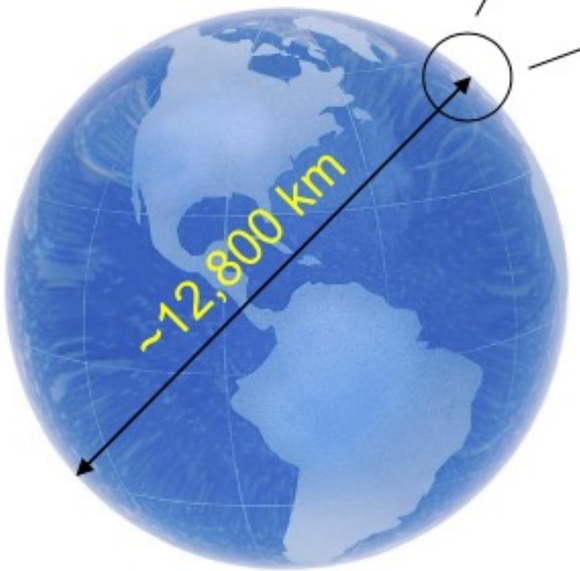
Wind Power and Wind Turbines

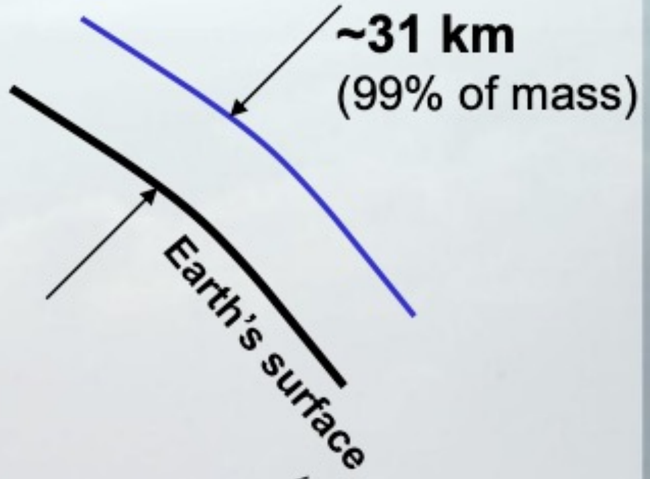
Outline

- Wind – causes?
- Wind Power – example
- Wind Turbine Design
  - Aerodynamics
- Electrical Power Converter

Wind – what causes it?

- **Atmospheric <u>pressure</u> differences**
  - **– Where does the pressure come from?**
    - **• Weight of air in atmosphere**

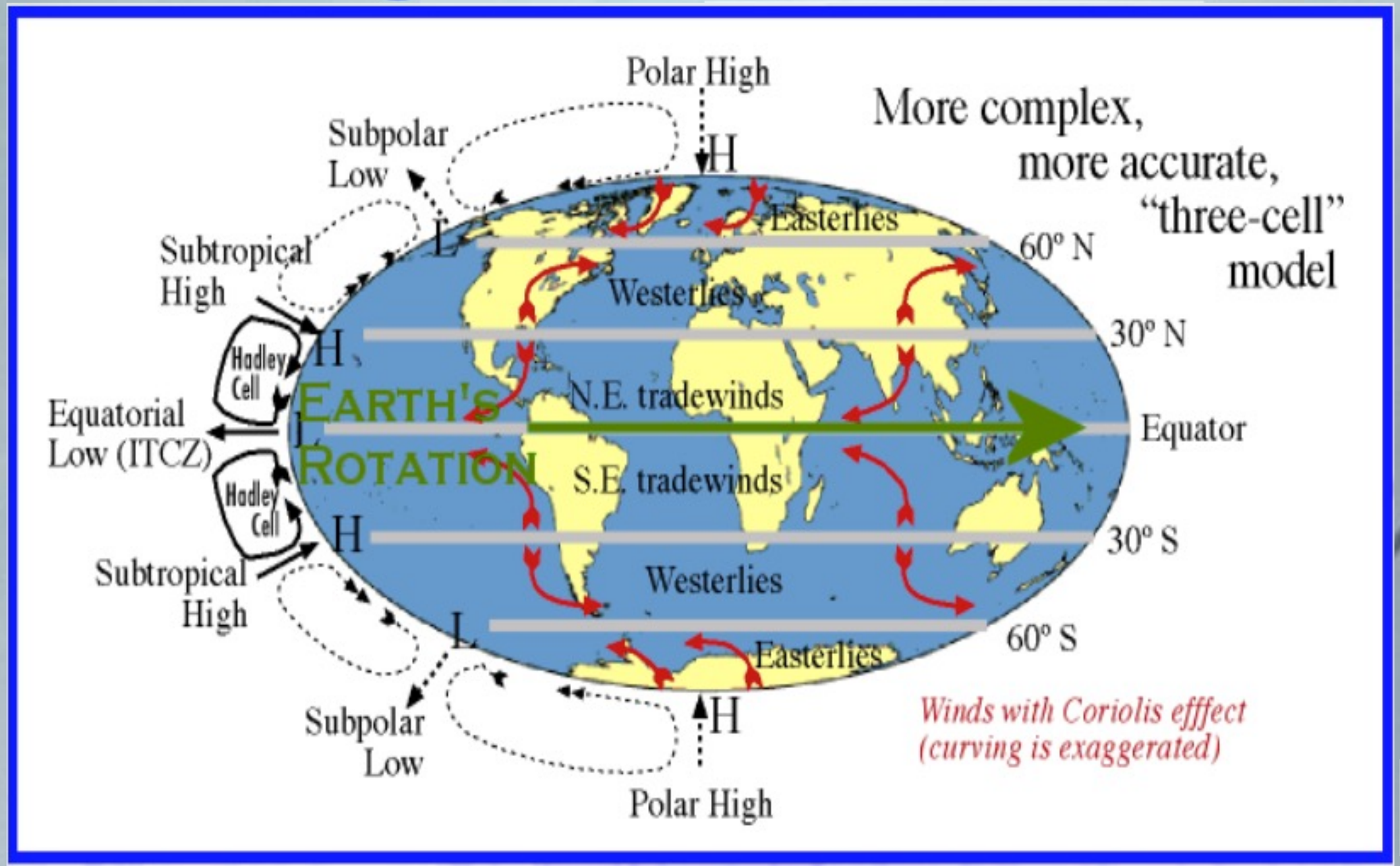




$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

- **Avg. pressure at sea level**
  - **– 101325 Pa (Pascal)**
  - **– 1013.25 mb (millibar)**
  - **– 29.92 in. Hg (inches of mercury**
  - **– 1 atm (atmosphere)**
  - **– 14.7 psi (pound per square inch)**

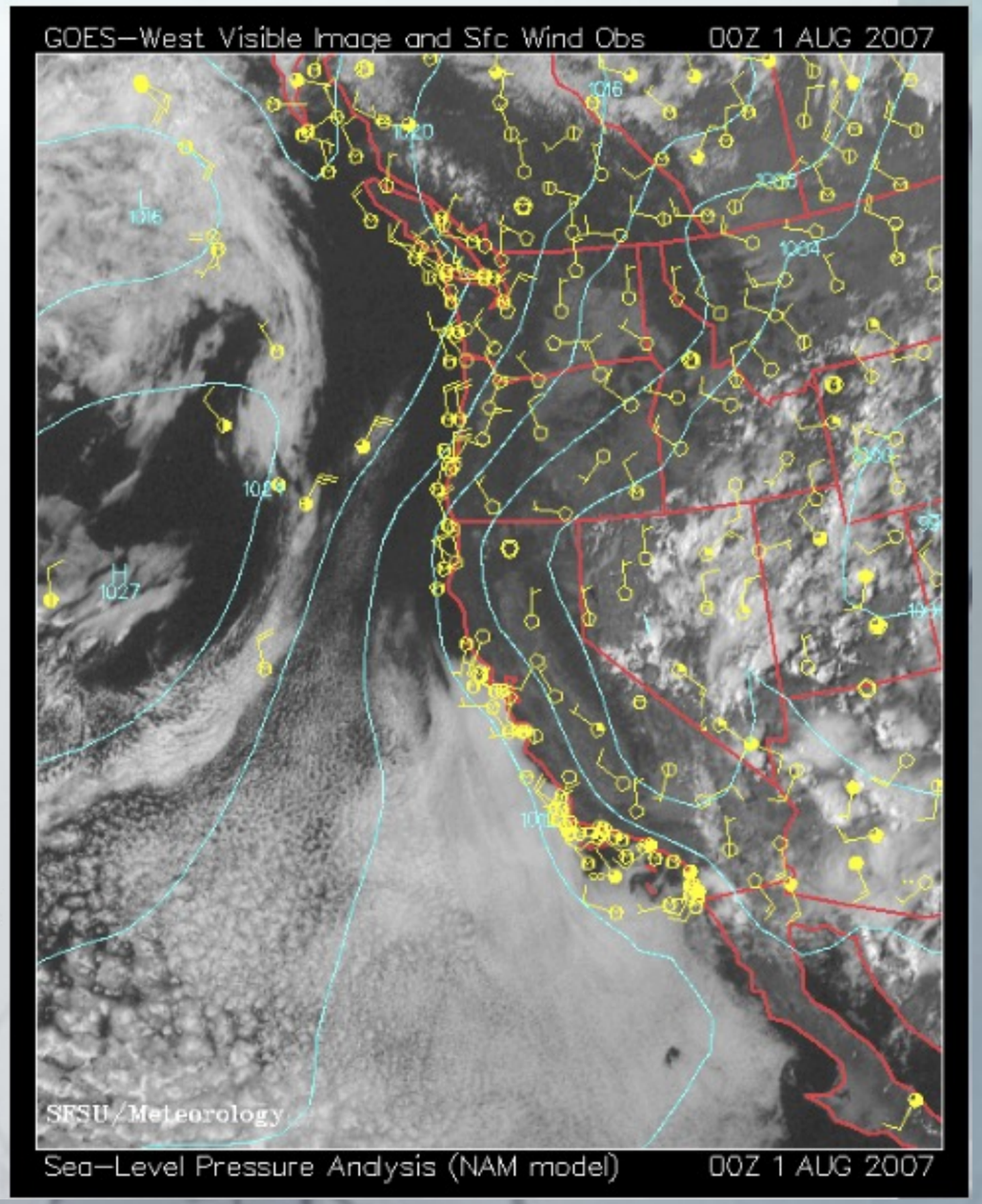
Prevailing Winds



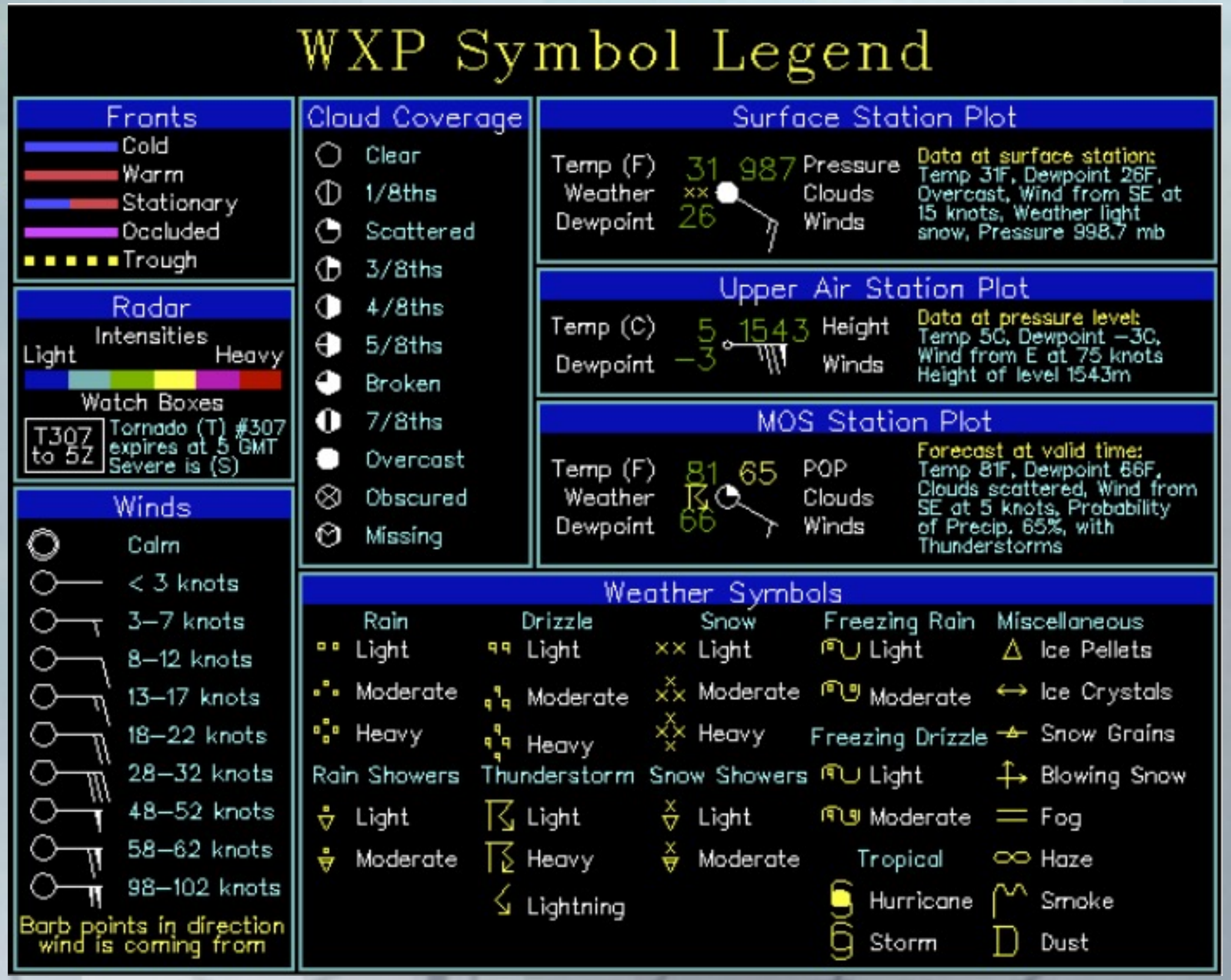
http://trampleasure.net/science/coriolis/coriolis.png

Wind – what causes it?, cont.

- **Pressure maps**
  - **– Contours of constant pressure (usually 4 mb between contours**
  - **– Close spacing means stronger winds**
  - **–In N.H., winds circulate around a low pressure region in CCW direction**



Weather Processor Symbols



1 knots = 0.154 m/s
= 1.852 km/h

http://trampleasure.net/science/coriolis/coriolis.png

Wind Energy and Power

- Atmospheric pressure differences accelerate and impart kinetic energy into the air
- Wind energy conversion machines (WEC) convert wind energy into electrical or mechanical forms
- How much *power* can we extract?

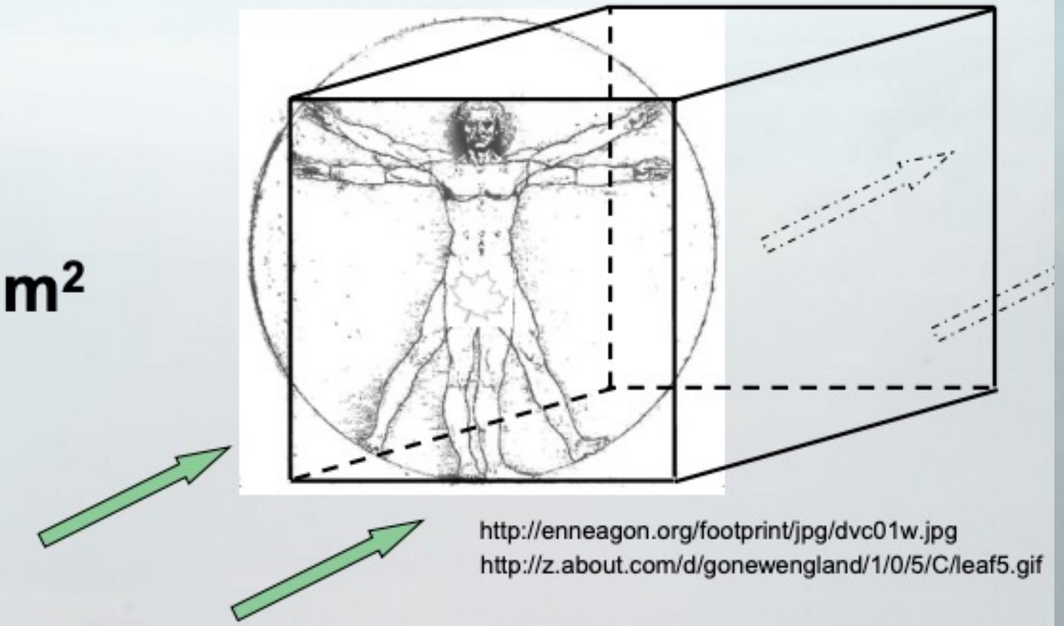
$$\text{Power} = \frac{\text{K.E.}}{\text{time}} = \frac{\frac{1}{2}(mass) \times (velocity)^2}{\text{time}}$$

$$\frac{mass}{time} = density \times area \times velocity$$

$$\boxed{\text{Power} = \frac{1}{2}(density) \times area \times (velocity)^3 = \frac{\rho A V^3}{2}}$$

Wind Power - Example

- **Example:**
  - **V = 10 m/s**
  - **A = (2 m)^2 = 4 m^2**
  - **ρ= 1.2 kg/m^3**



http://enneagon.org/footprint/jpg/dvc01w.jpg
http://z.about.com/d/gonewengland/1/0/5/C/leaf5.gif

$$\text{Power} = \tfrac{1}{2}(density) \times area \times (velocity)^3 = \frac{\rho A V^3}{2}$$

Wind Power – Example, cont.

$$P = \frac{\left(1.2\,kg/m^3\right)\left(4m^2\right)\left(10\,m/s\right)^3}{2}$$

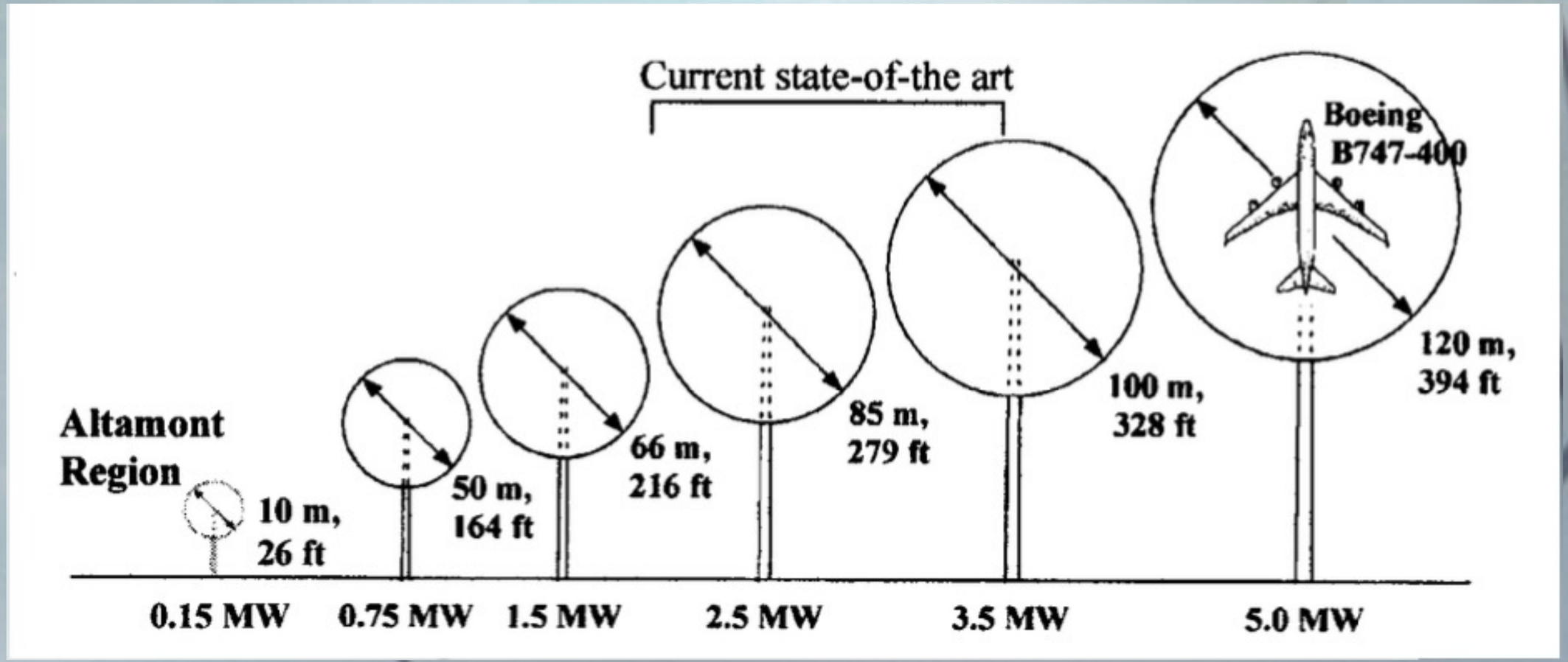
$$= 2400\frac{kg\cdot m^2}{s^3} = 2400\frac{kg\cdot m}{s^2}\cdot\frac{m}{s} = 2400\,N\cdot\frac{m}{s}$$

$$\boxed{P = 2400\frac{N\cdot m}{s} = 2400\,W}$$ **Theoretical Maximum**

Betz Limit: 59.3% of the theoretical is the maximum amount extractable by a wind energy conversion device (WEC)

$$\boxed{P_{Betz} = 0.593(2400W) = 1423.2W}$$ **Practical Maximum**

Wind Turbine Size-Power Comparison



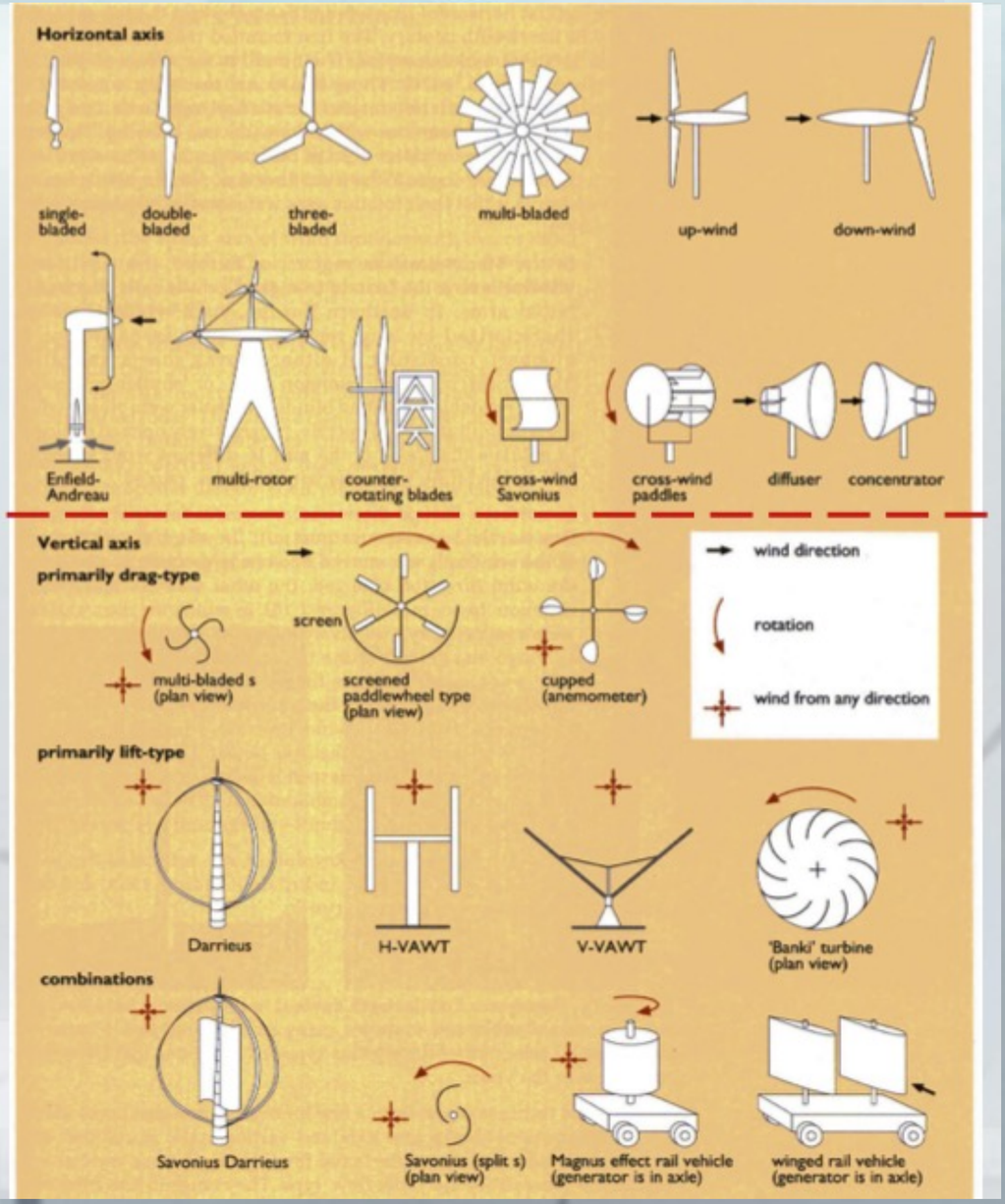
Wind Turbine Configurations

HAWT

Horizontal Axis Wind Turbin

VAWT

Vertical Axis Wind Turbin



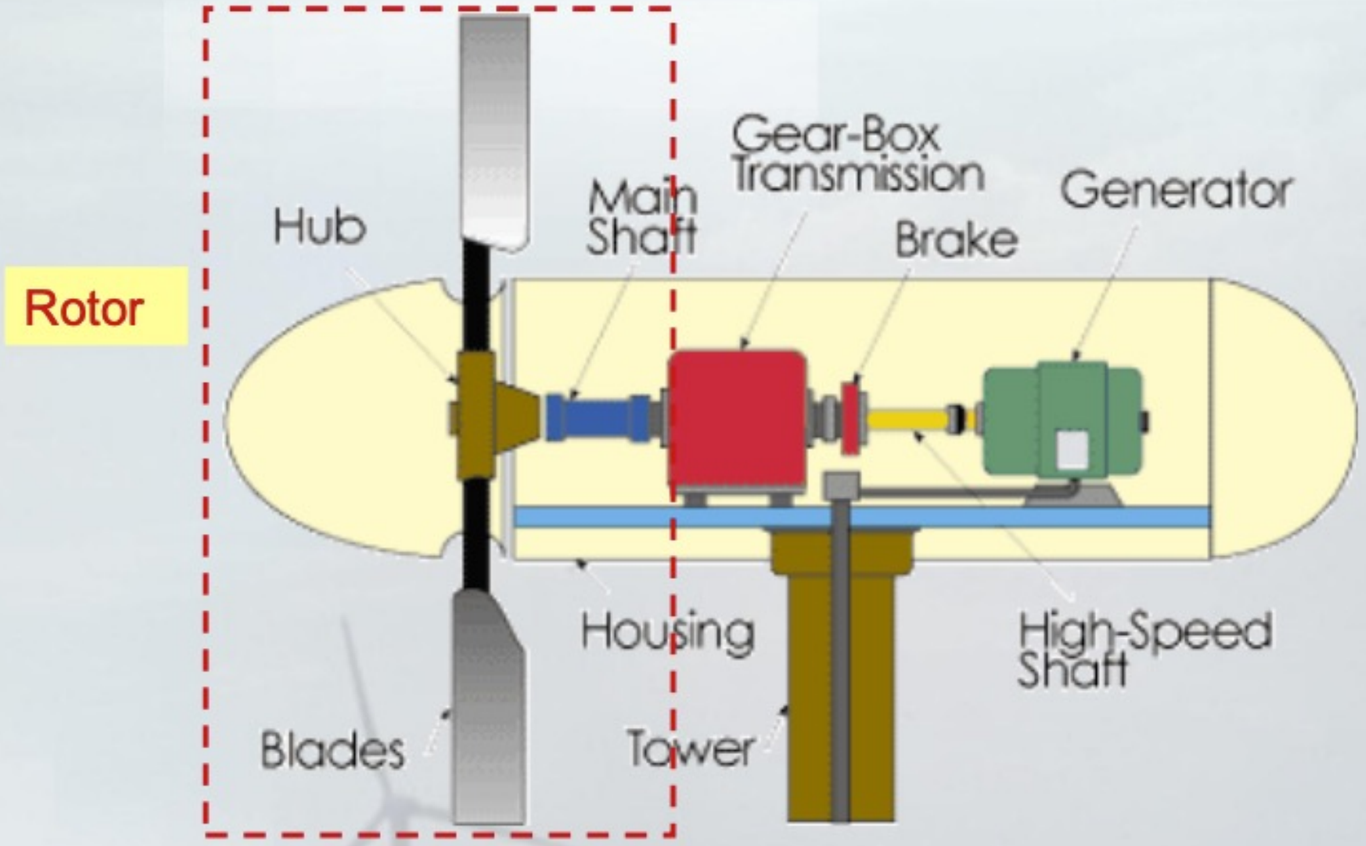
Boyle, G., Renewable Energy, 2nd ed., Oxford University Press, 2004

Configuration Tradeoffs

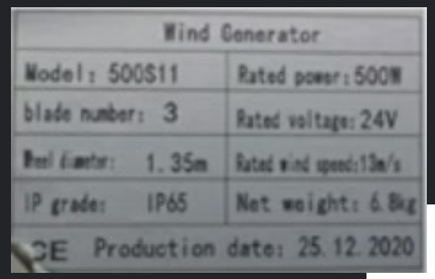
- Factors
  - Efficiency
    - Power produced per unit cost
  - Directionality
  - Support configuration
  - Speed of rotation
  - Reliability
  - Cost
  - Maintainability

Which type is *best, HAWT or VAWT*?

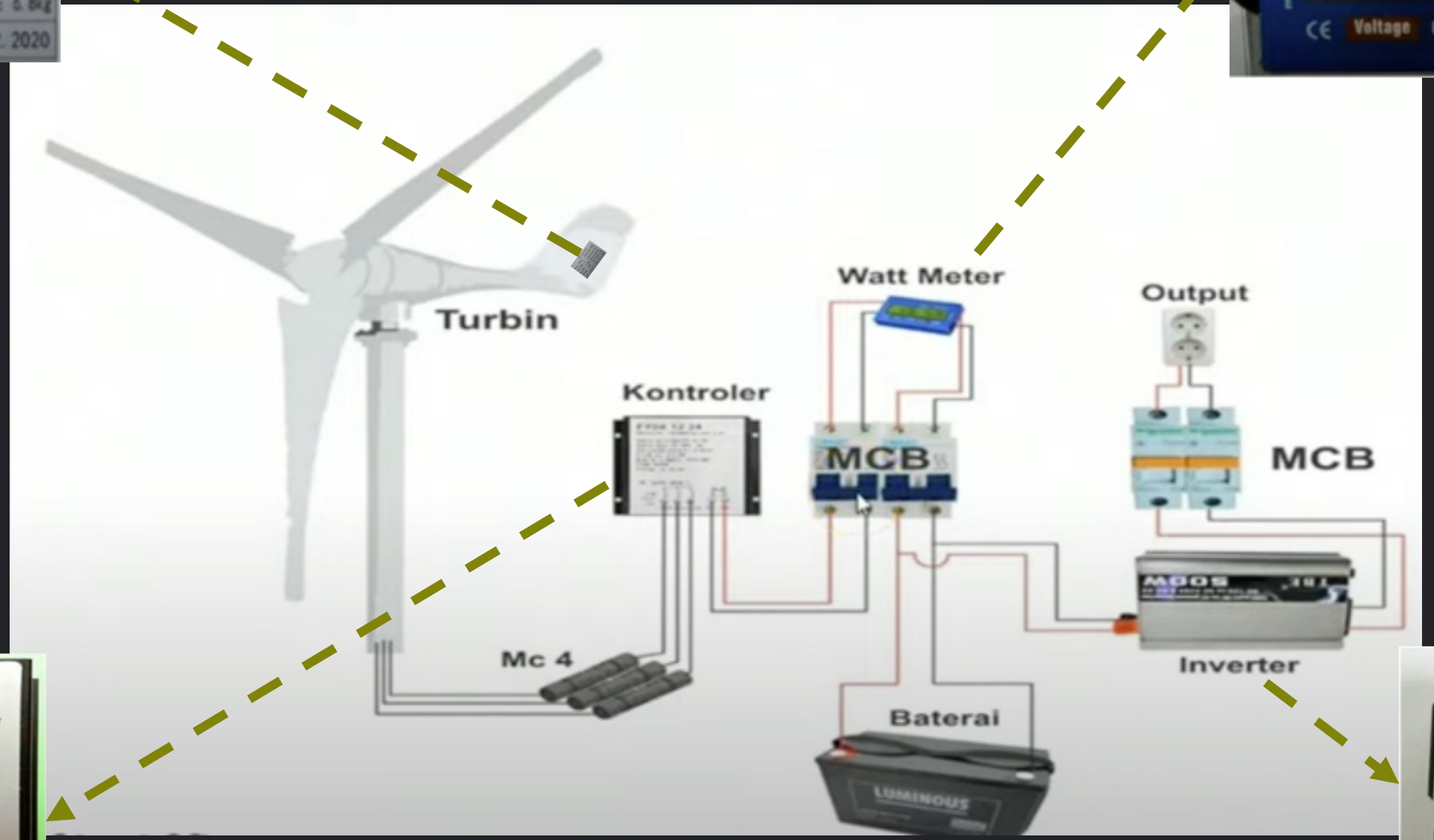
Common HAWT Construction

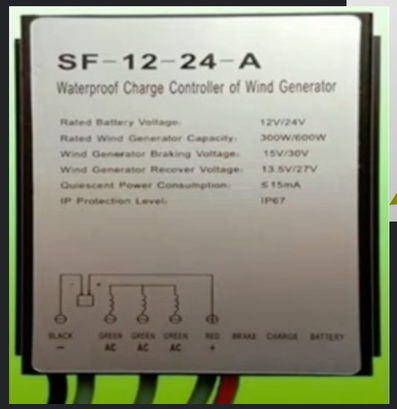


- **Blades are connected to a hub, which is connected to a shaft**
- **Rotational speed will depend on blade geometry, number of blades, and wind speed (40 to 400 revolutions per minute typical speed range)**
- **Gear box needed to increase speed to 1200-1800 RPM for generator**


Wind Generator
Model: 500S11
Rated power: 500W
blade number: 3
Rated voltage: 24V
Rated wind speed:10m/s
IP grade: IP65
Net weight: 6.8kg
Production date: 25.12.2020


Watt Meter
SOURCE
LOAD
0.00A 19.55V
0.0Wh 0.0W
Voltage 0-60V Current 0-100A


Turbin
Watt Meter
Output
Kontroler
MCB
MCB
Mc 4
Baterai
Inverter


SF-12-24-A
Waterproof Charge Controller of Wind Generator
Rated Battery Voltage: 12V/24V
Rated Wind Generator Capacity: 300W/600W
Wind Generator Braking Voltage: 15V/30V
Wind Generator Recover Voltage: 13.5V/27V
Quiescent Power Consumption: ≤15mA
IP Protection Level: IP67
BLACK GREEN GREEN GREEN RED BRAKE CHARGE BATTERY
AC AC AC +


500 watt DC to AC power inverter
DC 12V to AC 220V & DC 5V
TBE
500W

Implementasi

Xianjiang, China
Wind Farm = 2,3 GW

Yorkshire Beach, England
1,2 GW

PROS

- Tidak menghasilkan limbah, polusi, dan emisi.
- Sumber energi secara cuma-cuma.
- Space ruang yang digunakan berukuran kecil.
- Dapat dipadukan dengan sumber pembangkit lain.

CONS

- Memerlukan sumber angin yang cukup
- Bersifat *intermittent*
- Kondisi alam yang tidak mudah diprediksi
- Kerusakan akibat petir
- Mengganggu kehidupan alam liar
- Biaya perawatan besar
- Membutuhkan banyak turbin
- Bising

END