Benha University

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Benha University
Faculty of Engineering at Shoubra
Electrical Engineering Dept.

Postgraduate (Pre-master) Course

Generation of Electrical Power from Renewable Resources

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Syllabus

1. • ***INTRODUCTION.***
2. • ***SOLAR PHOTOVOLTAIC POWER SYSTEM.***
3. • ***SOLAR THERMAL POWER SYSTEM.***
4. • ***WIND POWER SYSTEM.***
5. • ***ENERGY STORAGE SYSTEMS.***
6. • ***STAND-ALONE SYSTEM.***
7. • ***GRID-CONNECTED SYSTEM.***

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Three Control Levels

1. The uppermost level is a supervisory controller that monitors the turbine and wind resource to determine when the wind speed is sufficient to start up the turbine and when, due to high winds, the turbine must be shut down for safety.

2. On the middle level is turbine control, which includes generator torque control, blade pitch control, and yaw control.
Generator torque control, and pitch control determines how much torque is extracted from the turbine, specifically, the high-speed shaft.
Yaw control, which rotates the nacelle to point into the wind, is slower than generator torque control and blade pitch control.

3. On the lowest control level controllers are the internal generator, power electronics, and pitch actuator, which operate at higher rates than the turbine-level control

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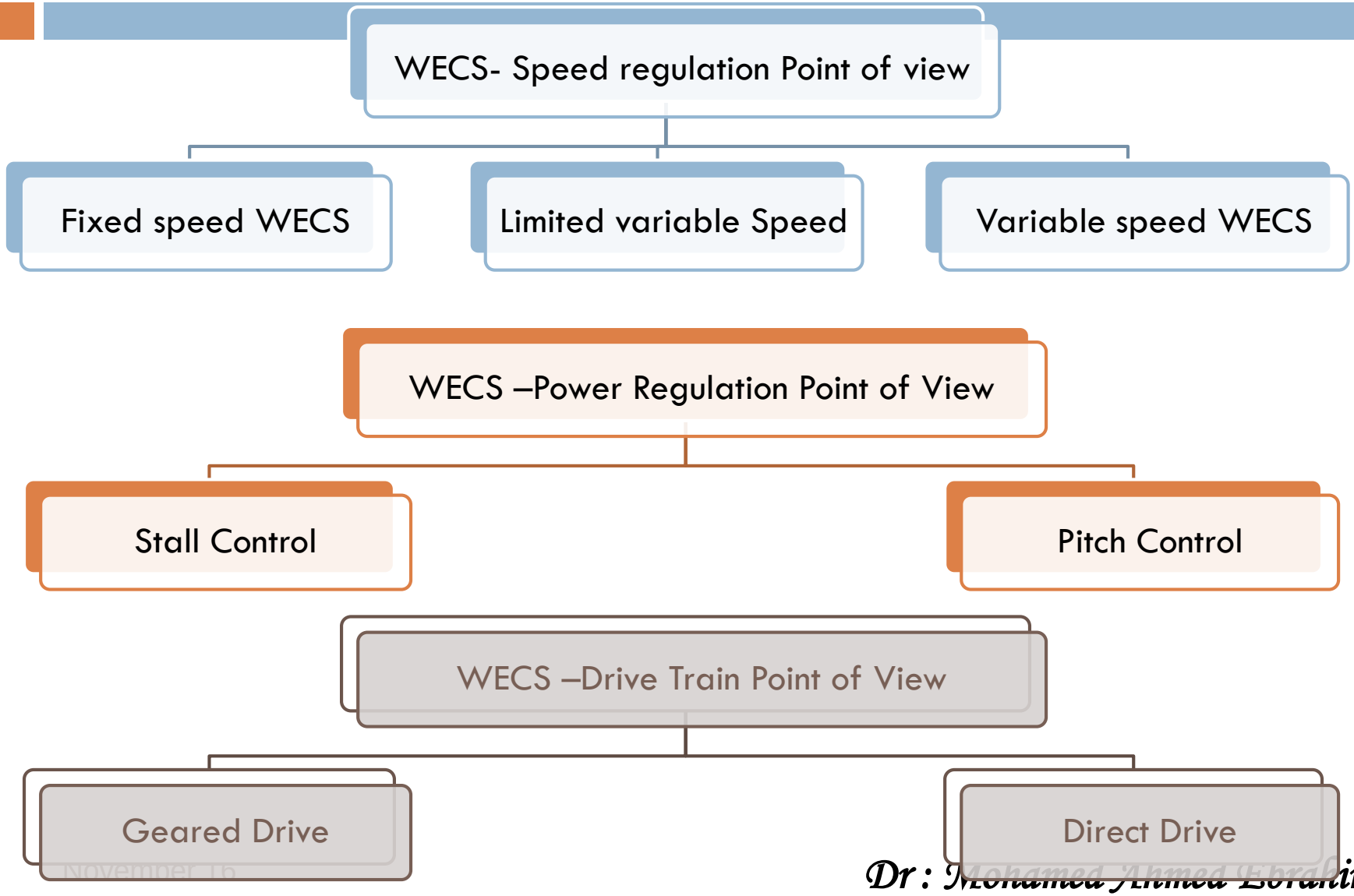
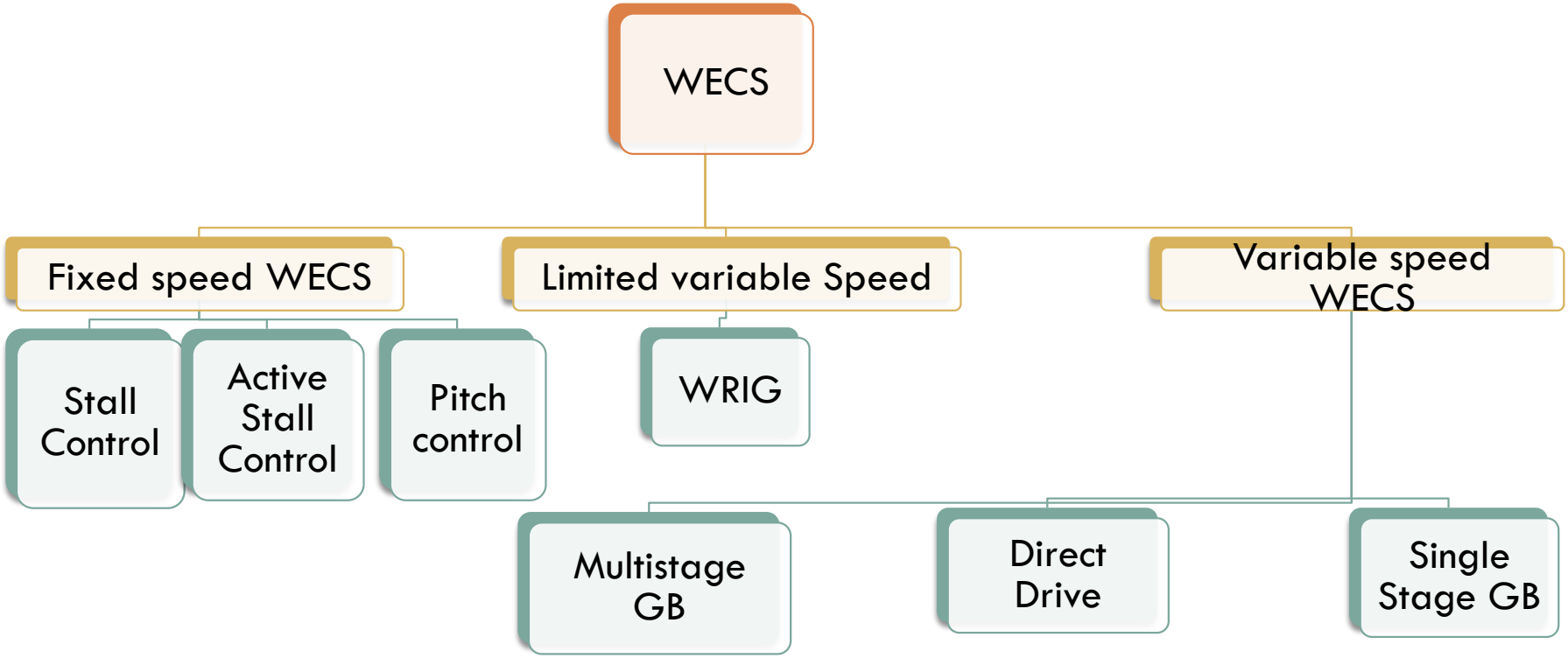
Wind Energy control Systems (WECS) Configuration

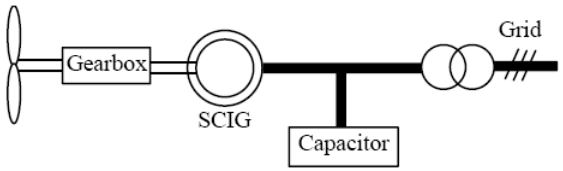



WECS
Fixed speed WECS
Limited variable Speed
Variable speed WECS
Stall Control
Active Stall Control
Pitch control
WRIG
Multistage GB
Direct Drive
Single Stage GB

WECS

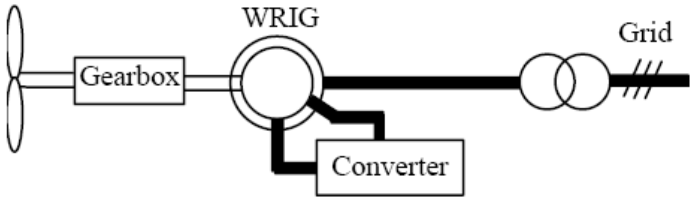
Fixed speed WECS

- Stall Control
- Active Stall Control
- Pitch Control



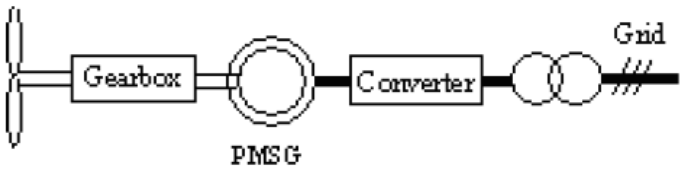
Limited variable Speed

- WRIG



Variable speed WECS

- Multi Stage Gearbox
  - DFIG
  - SCIG
  - PMSG
- Direct Drive Control
  - EESG
  - PMSG
- Single Stage Gearbox



Wind Turbine Systems

WECS

- Fixed speed WECS
- Limited variable Speed
- Variable speed WECS

advantage

- Low cost

Disadvantages

- Low efficiency
- Poor power quality

advantages

- Better Efficiency
- Better Power Quality

Disadvantages

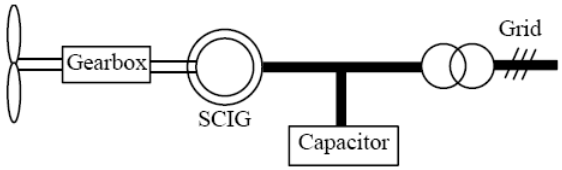
- Higher Cost

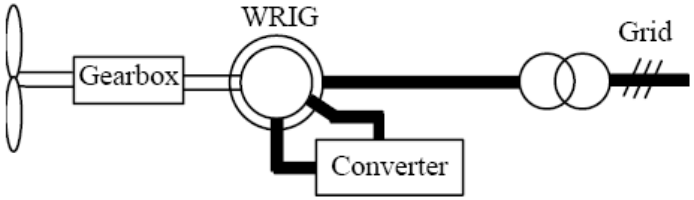
advantages

- High Efficiency
- Improved Power Quality

Disadvantages

- High Cost





Wind Turbine Systems (Cont.)

Variable Speed – 3 Stage Gearbox

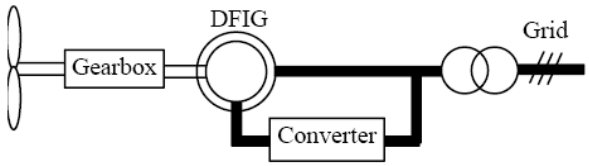
DFIG

advantage

- 20% Power converter

Disadvantage

- Gear box



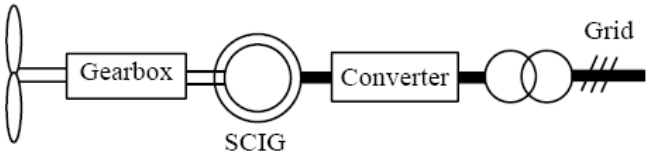
SCIG

advantages

- Less cost of machine
- Less weight

Disadvantages

- 120% Full Power rating converter
- Gear box



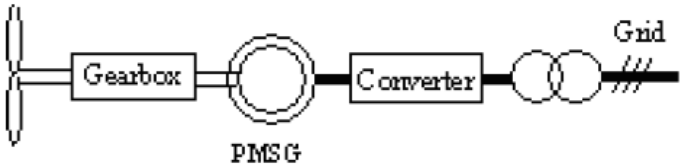
PMSG

advantage

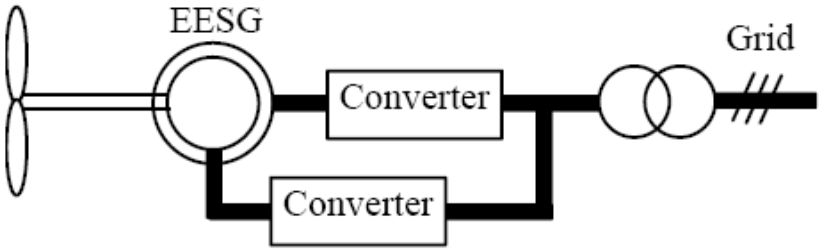
- Better efficiency
- Brushless

Disadvantage

- 120% Full Power rating converter
- Gear box
- Requires cooling to protect Magnets
- Magnets Cost

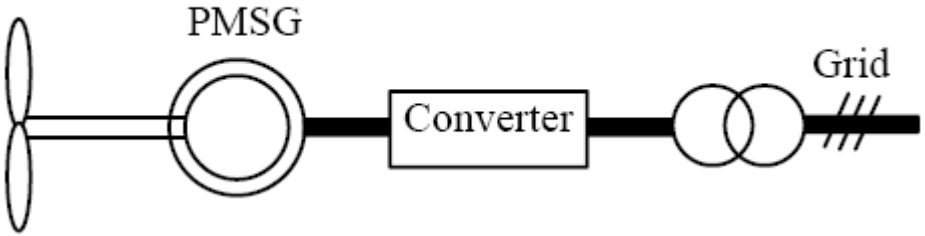


- Variable speed WECS
  - Multistage GB
  - Single Stage GB
    - EESG
    - PMSG
  - Direct Drive
    - EESG
    - PMSG



$$n_s = \frac{60\,f}{p}$$

$p \uparrow$ bigger machine size



advantage

- No Gear box
- Brushless

Disadvantage

- Full Power rating converter
- Heavy weight
- Higher cost

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Variable speed SG-Direct Drive

EESG

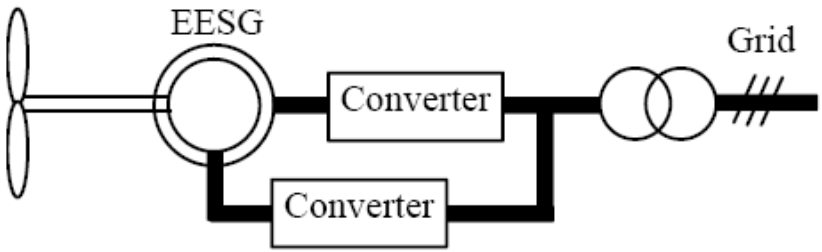
$$n_s = \frac{60\,f}{p} \qquad p \uparrow \text{ bigger machine size}$$

advantage

- Less Magnets cost

Disadvantage

- Slip ring
- Heavier



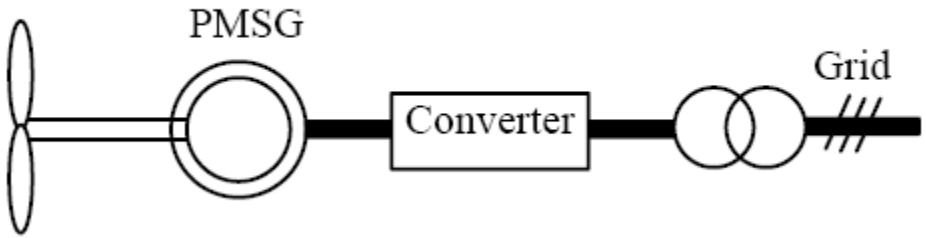
PMSG

advantage

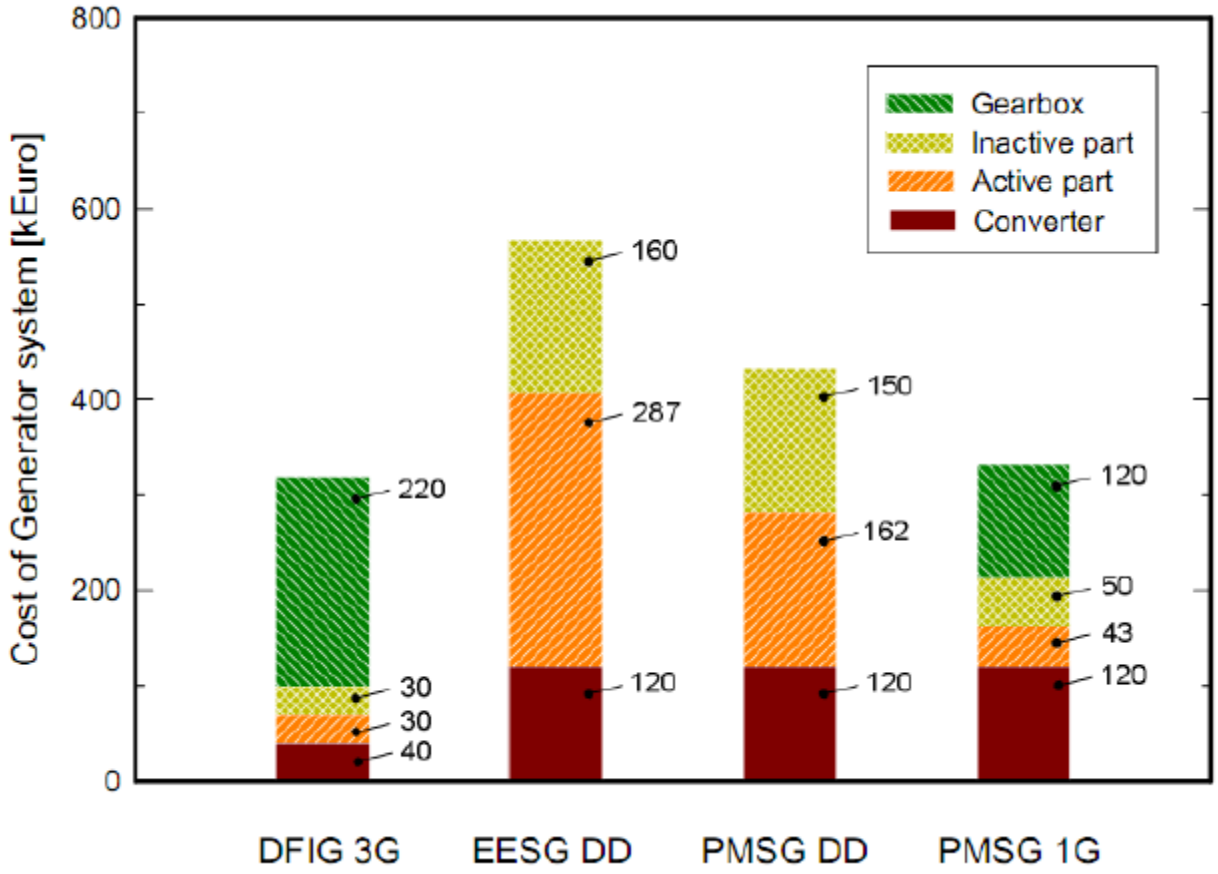
- Higher efficiency and energy yield.
- No additional power supply for the magnetic field excitation.
- Improved thermal characteristics due to the absence of field losses.
- Higher reliability due to the absence of mechanical components such as slip rings.
- Lightweight, hence higher power to mass ratio.

Disadvantage

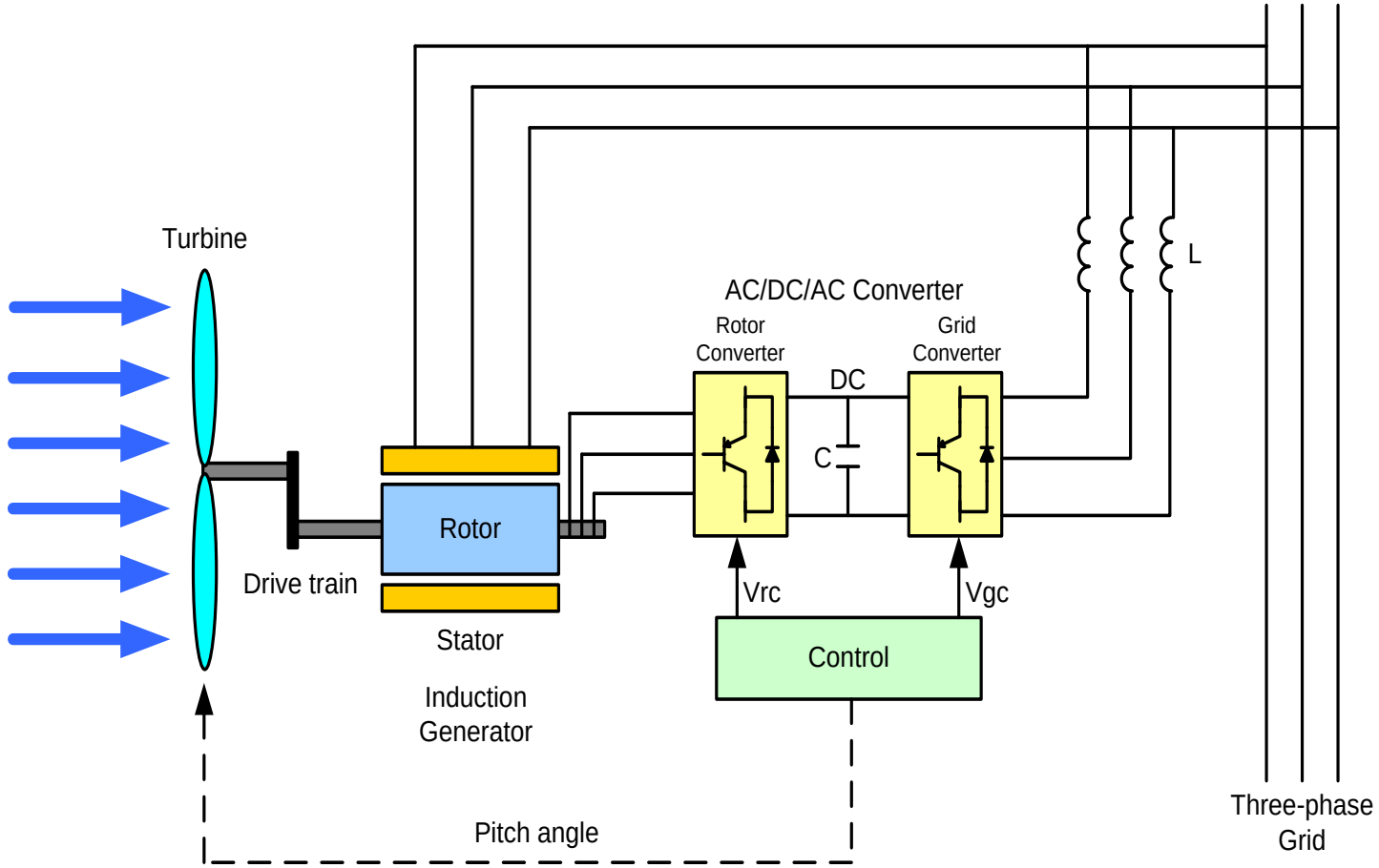
- High cost of PM.
- High cost of the converter.
- Difficulties to handle in manufacture.
- Demagnetization of PM at high temperature due to severe loading or short circuit.



Cost of Different Generator System

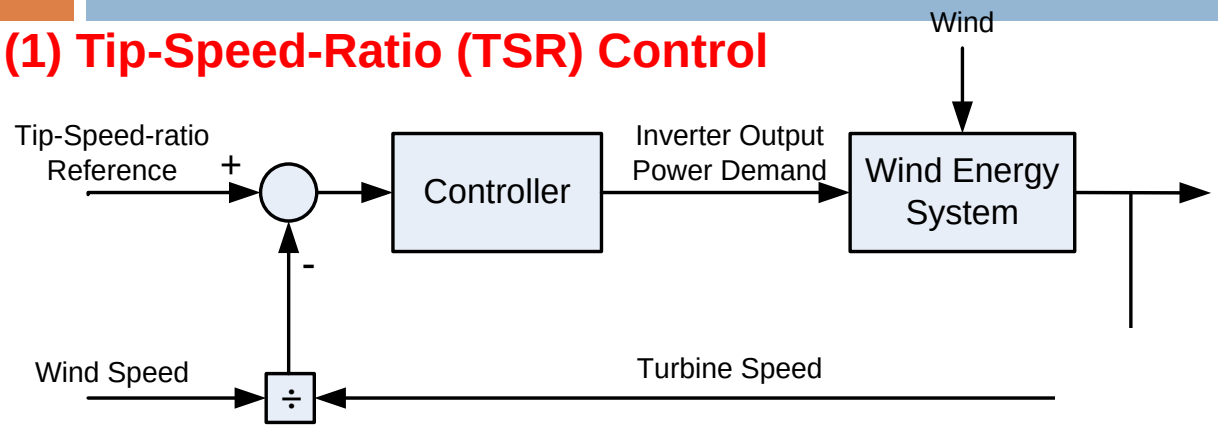


DFIG Configuration

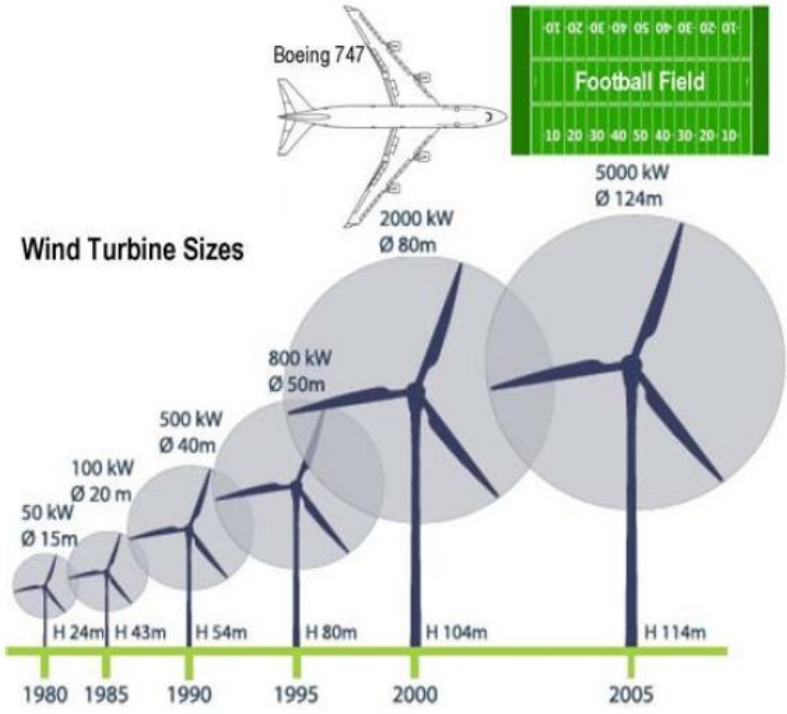


Review of Maximum Power Point Tracking Techniques

(1) Tip-Speed-Ratio (TSR) Control



TSR Problem ➡ **Wind Speed Measurement**



Source: www.renewableenergy.no, www.aerospaceweb.org/aircraft/jetliner/b747, and en.wikipedia.org/wiki/american_football

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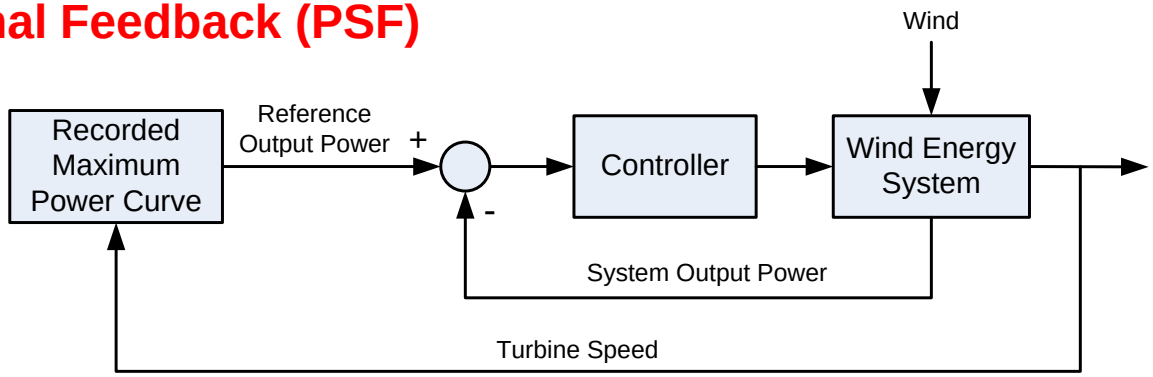
Review of Maximum Power Point Tracking Techniques (Cont.)

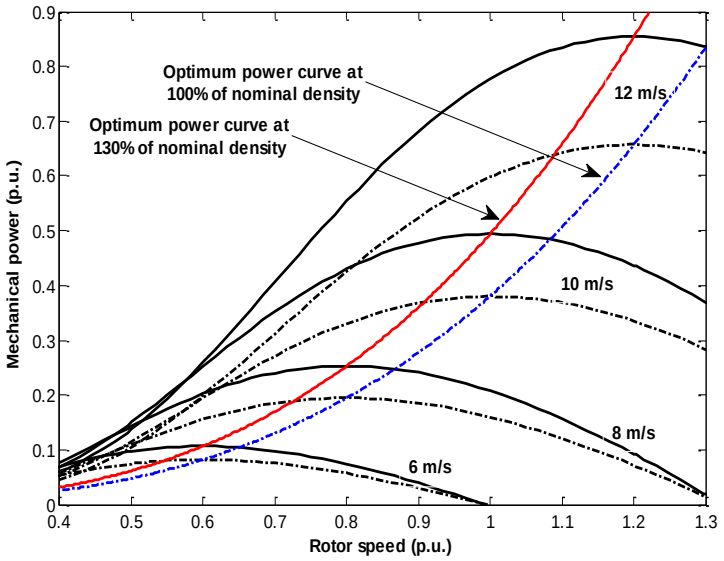
(2) Power Signal Feedback (PSF) Control



PSF Problem ➡ **Uncertainties of Power Curves**

$$P_m = \frac{1}{2} C_p(\lambda, \beta) \rho A V_{wind}^3$$

30% $\rho \uparrow$ ➡ **Cold Air**



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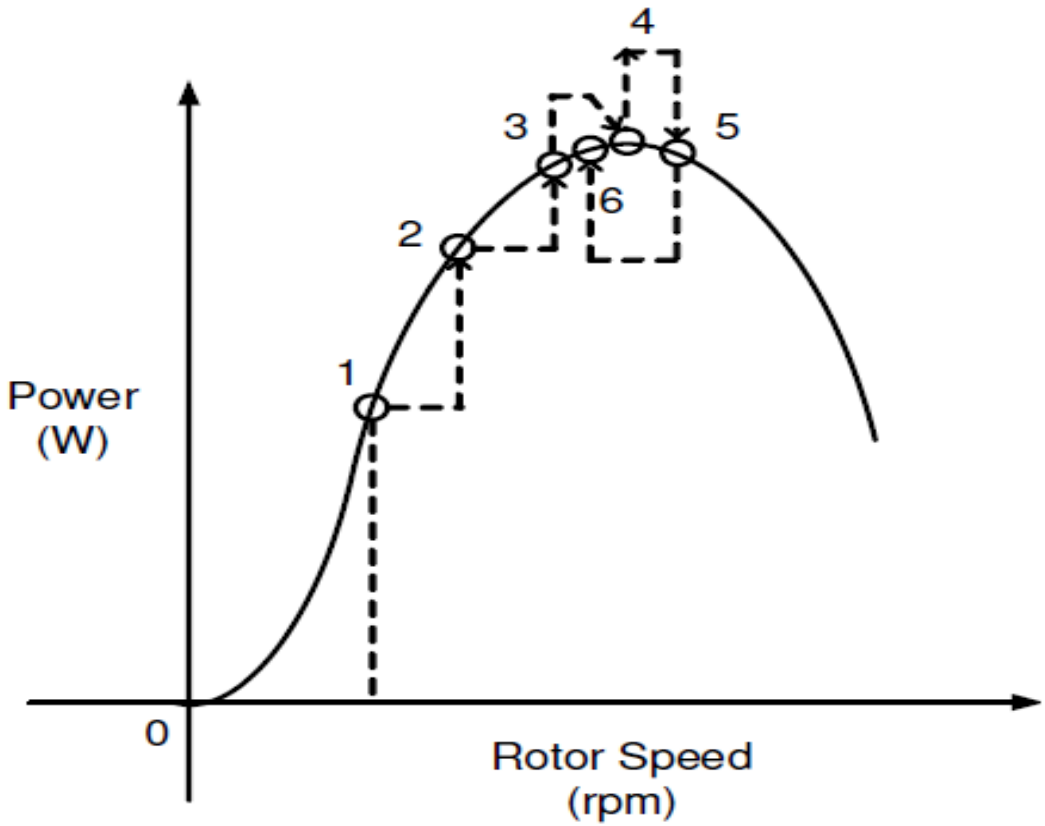
Review of Maximum Power Point Tracking Techniques (Cont.)

(3) Hill Climb Search (HCS)



Source: Joanne Hui , **"**An Adaptive Control Algorithm for Maximum Power Point Tracking for Wind Energy Conversion Systems," Master Thesis, Queen's University, Canada, 2008.

HCS Problem → **Slow Search**

Thank You For Your Attention

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