Renewable Energy Technology

Department of EEE
Faculty of Engineering
American International University-Bangladesh

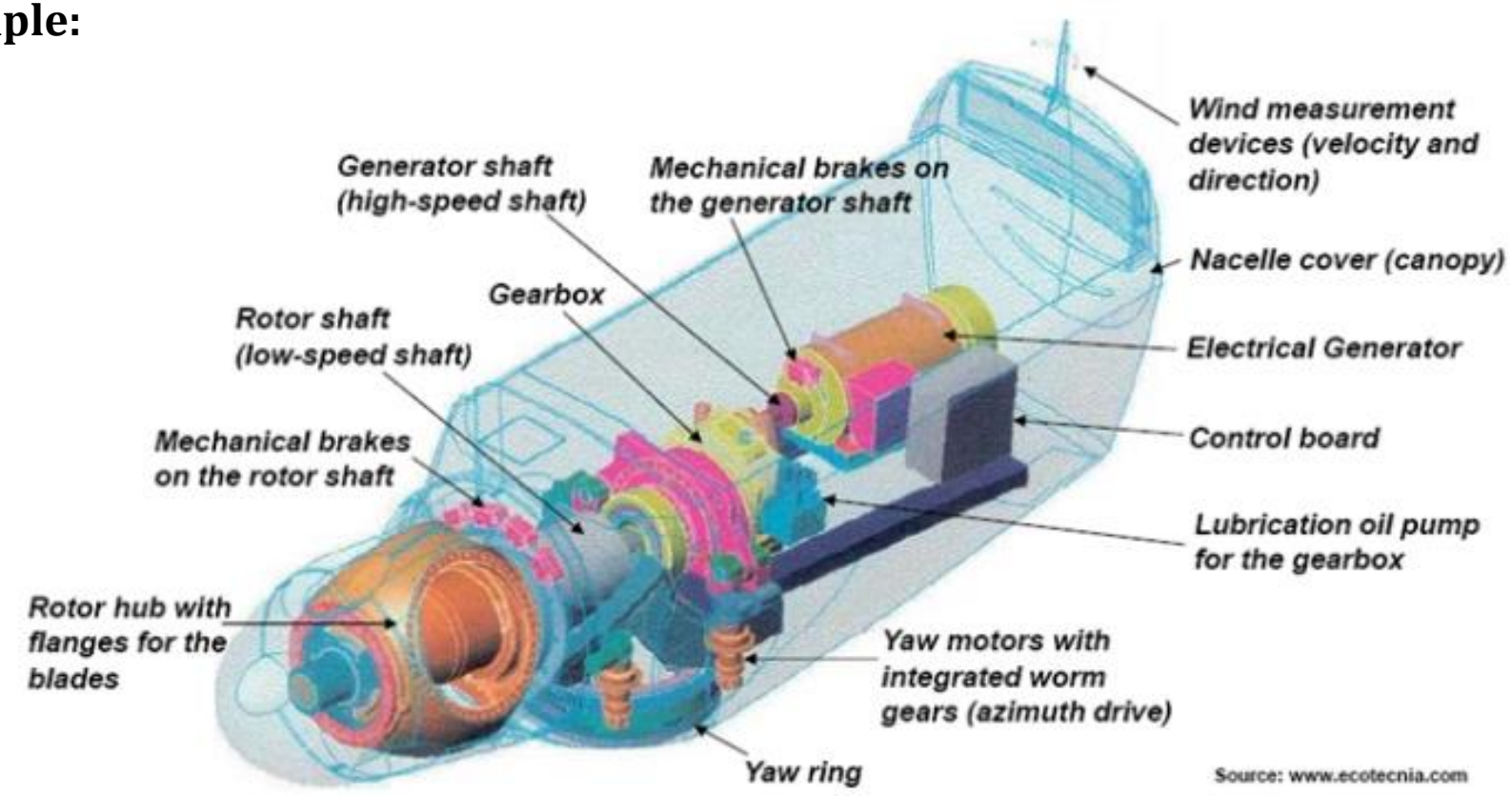
Wind Energy (Part 2)

Department of EEE
Faculty of Engineering
American International University-Bangladesh

Machines Elements of Wind Turbine

Major Components of HAWT

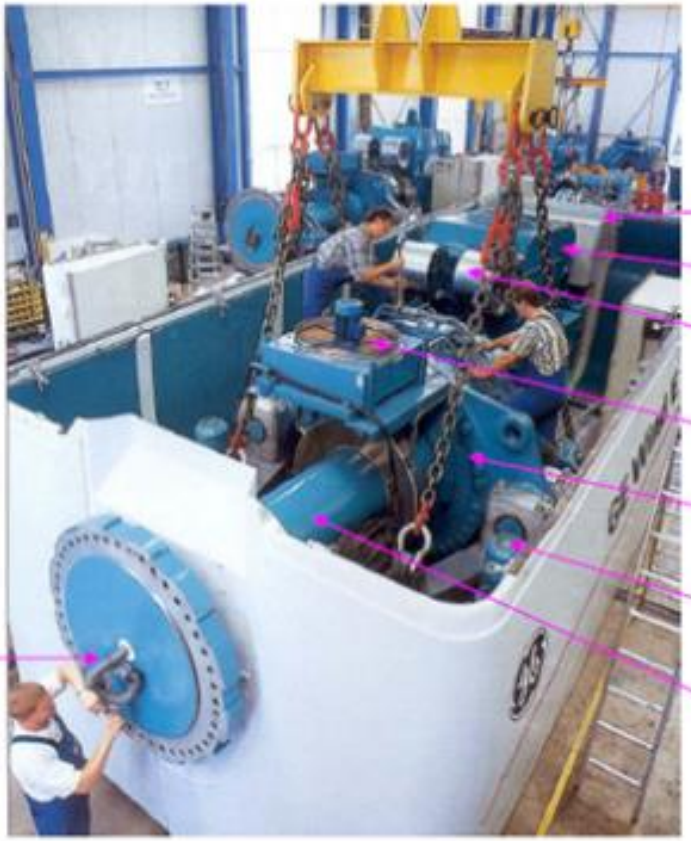
The layout of a typical HAWT. The 1.3 MW machine from Ecotècnia, Spain, as an example:



Machines Elements of Wind Turbine

Machines Elements of Wind Turbine

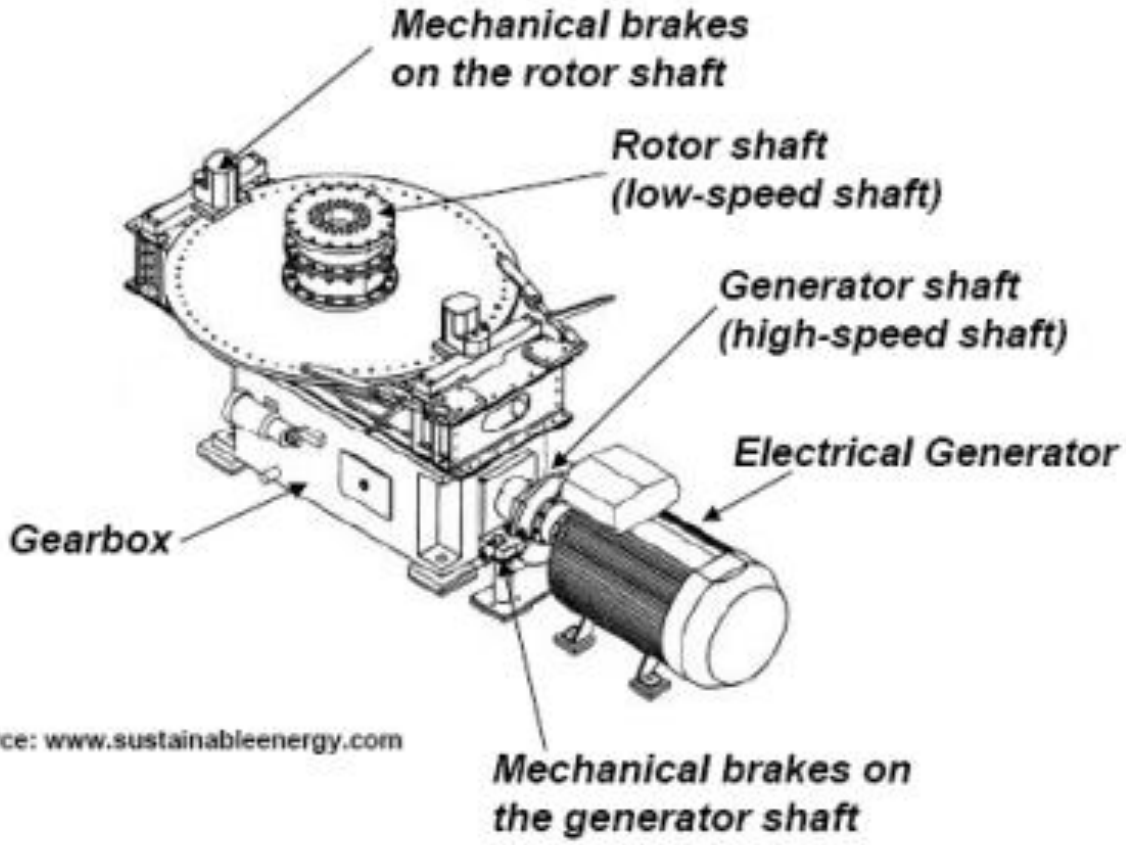
The 1.5 MW "GE Wind Energy" machine on the assembly line:



Source: Turbomachinery International, Jan/Feb 2003, www.turbomachinerymag.com

Machines Elements of Wind Turbine

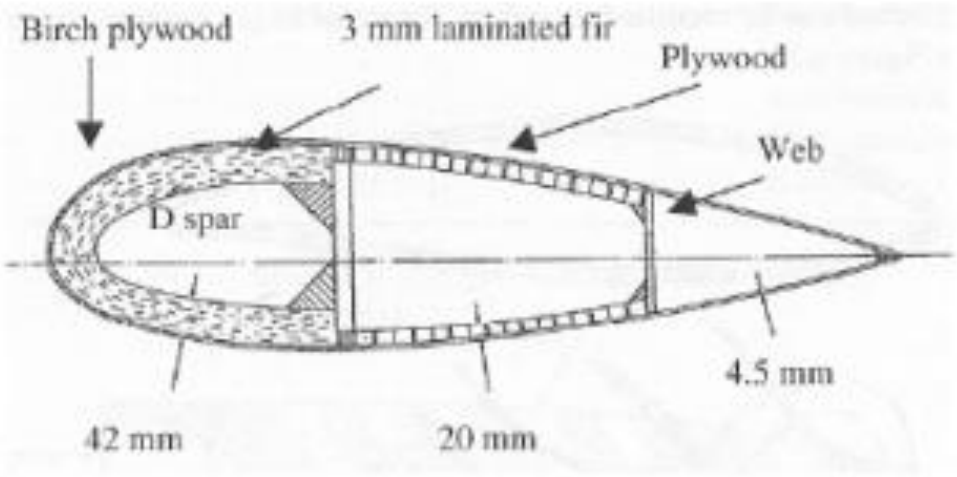
Drivetrain of a VAWT:



Machines Elements of Wind Turbine

Manufacturing Blades for a HAWT:

Structure of a wood-laminate blade



Source: "Wind Energy Explained", J. F. Manwell et al.

Machines Elements of Wind Turbine

Manufacturing Blades for a HAWT:

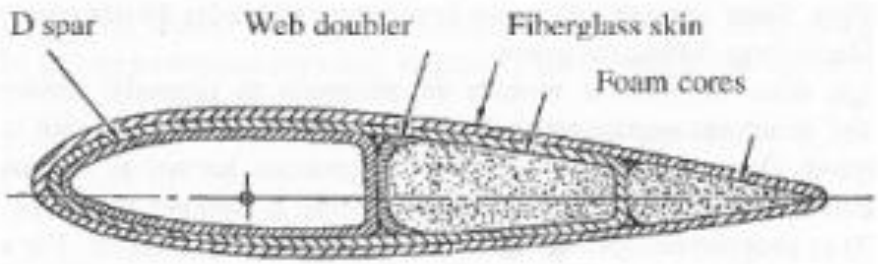
- The blades are the most critical component of the wind turbine.
- They should have the proper shape and be strong elastic and as lightweight as possible.
- One suitable material for blade manufacture is the wood.
- Novel lightweight materials used for modern blades are the glass-reinforced or carbon-reinforced polyester or epoxy resin.

Machines Elements of Wind Turbine

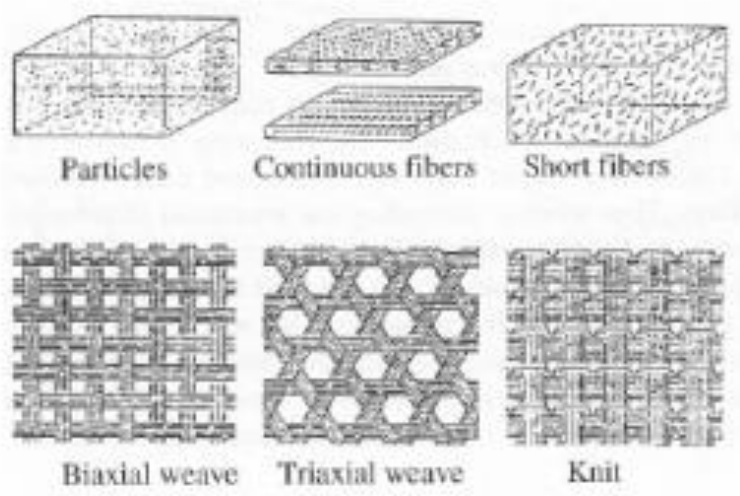
Manufacturing Blades for a HAWT:

Most modern blades are made of the comparatively cheap and mechanically suitable glass-reinforced polyester or epoxy resin or the more expensive (but stronger) carbon-fiber reinforced polyester or epoxy resin.

Structure of a typical glass-reinforced polyester blade



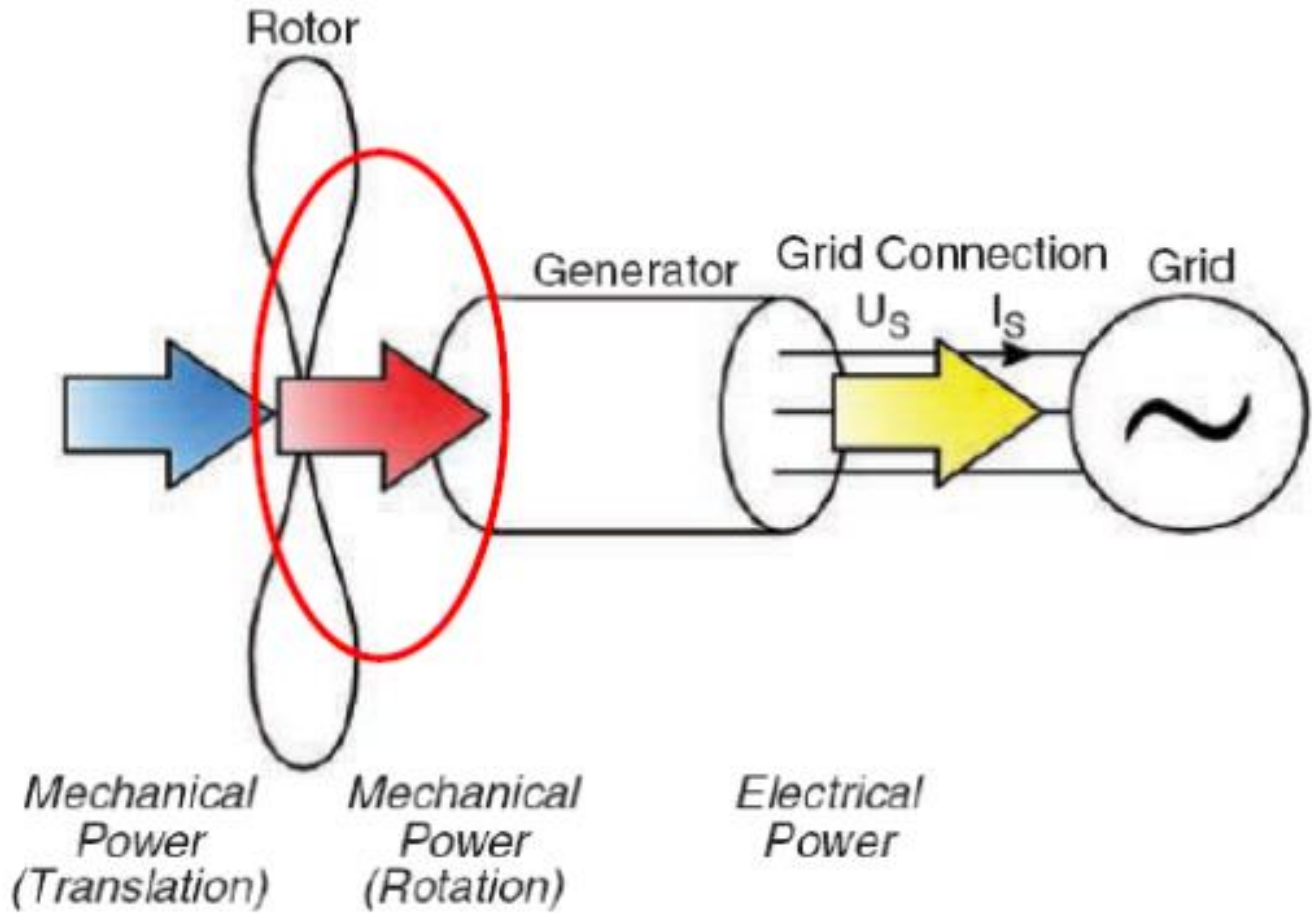
Glass fibres and types of woven glass fabric



Source: "Wind Energy Explained", J. F. Manwell et al.

Machines Elements of Wind Turbine

Shafts and Hubs in a HAWT:



Machines Elements of Wind Turbine

Shafts and Hubs in a HAWT:

- The rotor shaft must be able to sustain all loads from the blades without strain or deformations.
- The torque exerts a torsional moment on the shaft.
- The steady thrust force is much larger than the torque and is transferred by the shaft to the bearings, tower and foundation of the turbine.
- The generator shaft runs at much higher rpm, so the torque is small and the shaft is much thinner than the rotor shaft.
- The hub is the link between the rotor shaft and the blades. It supports the blades and contains the blade pitching motors and gears, which are usually powered and controlled via the hollow rotor shaft.

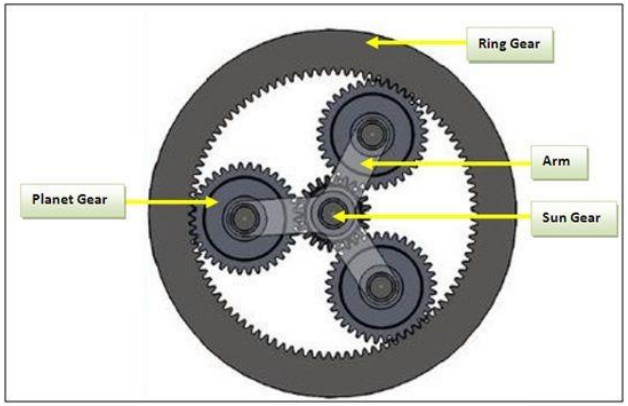
Machines Elements of Wind Turbine

Gearboxes:

- The gearbox transforms the high-torque low-rpm power of the turbine rotor shaft into low-torque high-rpm power for the generator shaft.

There are two basic types of gears used in the drivetrain of a wind turbine:

- Helical (parallel shaft)
- Planetary (epicyclic)

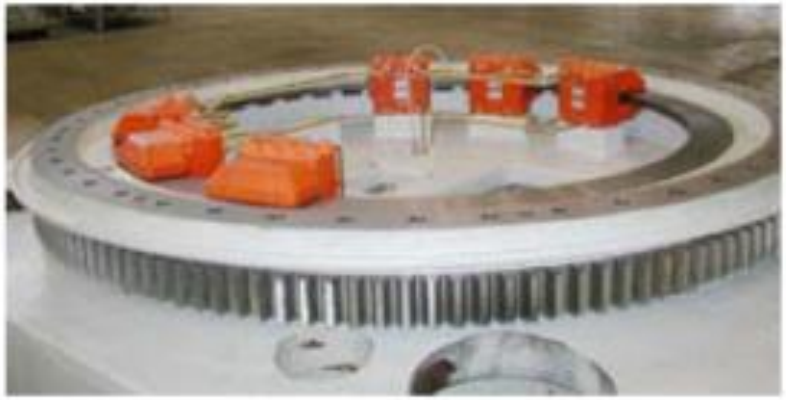


Machines Elements of Wind Turbine

Mechanical Brakes:

- Mechanical brakes (disk brakes with metal pads and hydraulic actuation) are a very crucial component for the wind turbine.
- They are always present at the generator shaft and sometimes also on the rotor shaft.

Brakes on the yaw ring



Brakes on the generator shaft

Source: www.svendborg-brakes.dk

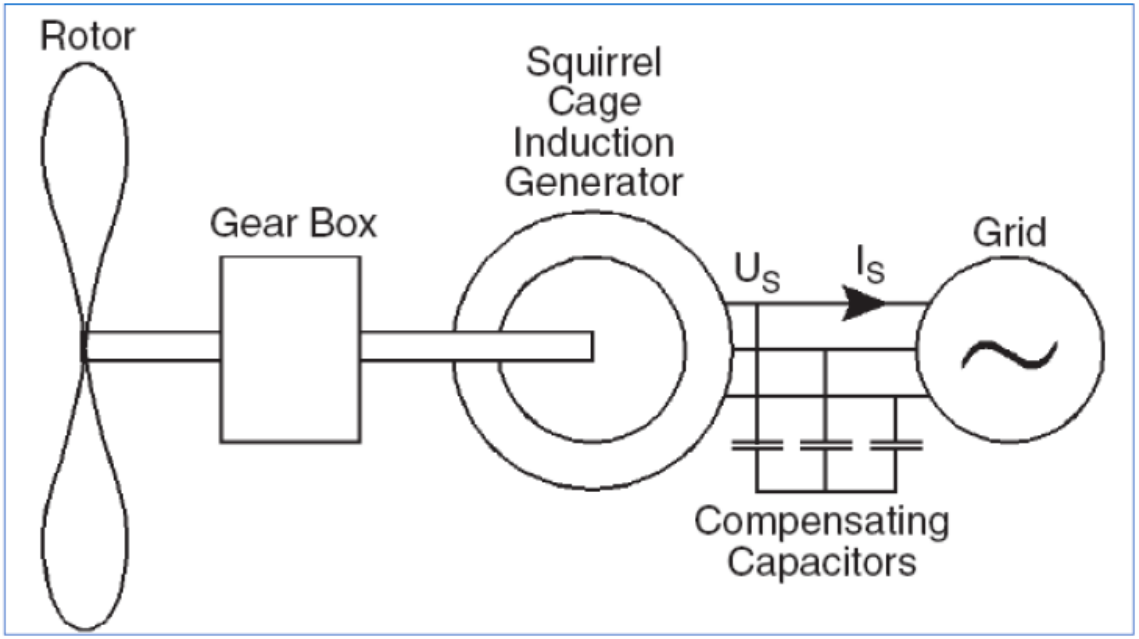
Wind Turbine Generator Technology

The wind turbine can be:

- **Fixed Speed Wind Turbine with Squirrel Cage Induction Generator (FSWT-SCIG).**
- **Variable Speed Wind Turbine with Permanent Magnet Synchronous Generator (VSWT-PMSG).**
- **Variable Speed Wind Turbine with Synchronous Generator (VSWT-SG).**
- **Variable Speed Wind Turbine with Doubly Fed Induction Generator (VSWT-DFIG).**

Wind Turbine Generator Technology

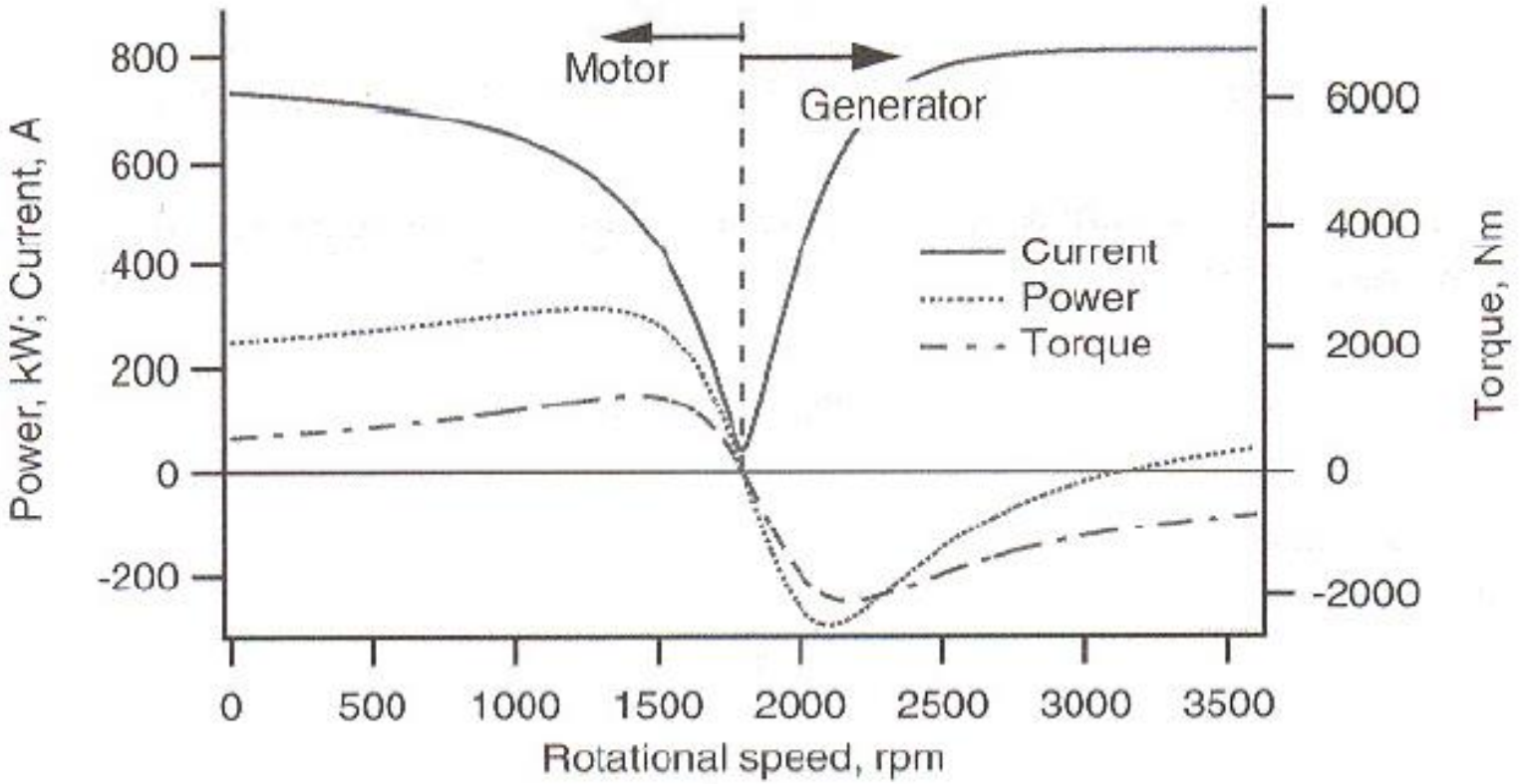
"Constant" speed Wind turbine/FSWT



The induction machines always consume reactive power in order to operate.

Wind Turbine Generator Technology

Operation of Induction Machine:

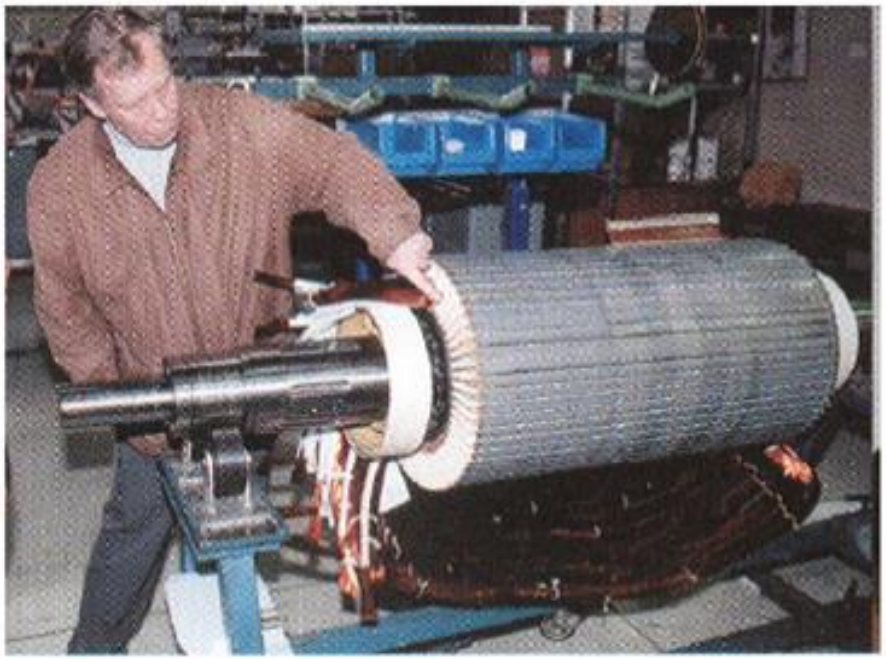


Source: "Wind Energy Explained", J. F. Manwell et al.

Wind Turbine Generator Technology

Doubly Fed Induction Generator (DFIG):

Induction generators with "double-feed" wounded rotors are used in most modern multi-MW wind turbines, aiming at improving the output power quality and allowing for wider window of variable speed operation.

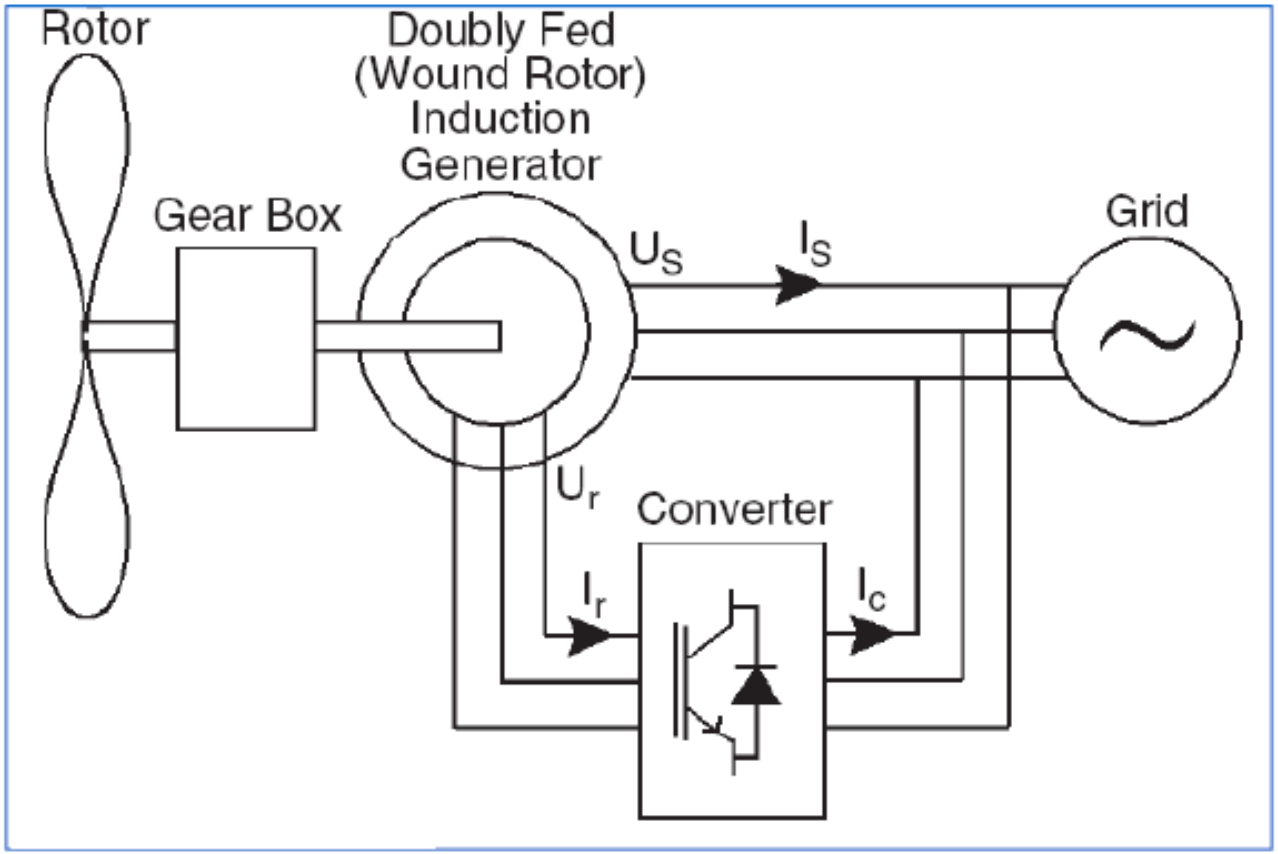


The rotor of a double-feed induction generator for windmill applications

Source: DEWIND magazine Nr.7 / 2002

Wind Turbine Generator Technology

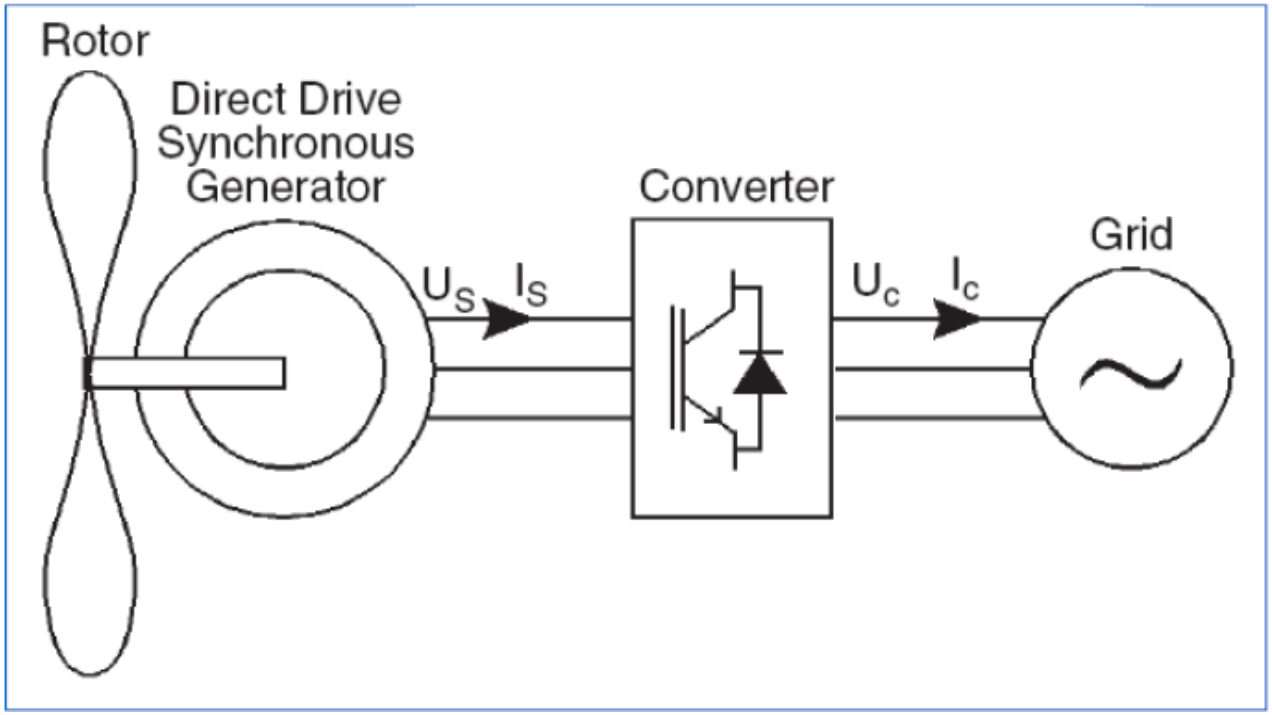
Variable Speed Wind Turbine Doubly Fed Induction Generator (DFIG):



*DFIG=doubly fed induction generator
(also known as wound rotor induction generator)

Wind Turbine Generator Technology

Variable Speed Wind Turbine with Synchronous Generator:



- Synchronous machines run in full synchrony with the frequency of the electrical grid.

- They must be specifically designed for such a service and require special procedures when connecting to the grid.
- However, if supported by power electronics, they allow for variable operation of the turbine, which provides aerodynamic advantages.

Wind Turbine Generator Technology

Permanent Magnet Generators:

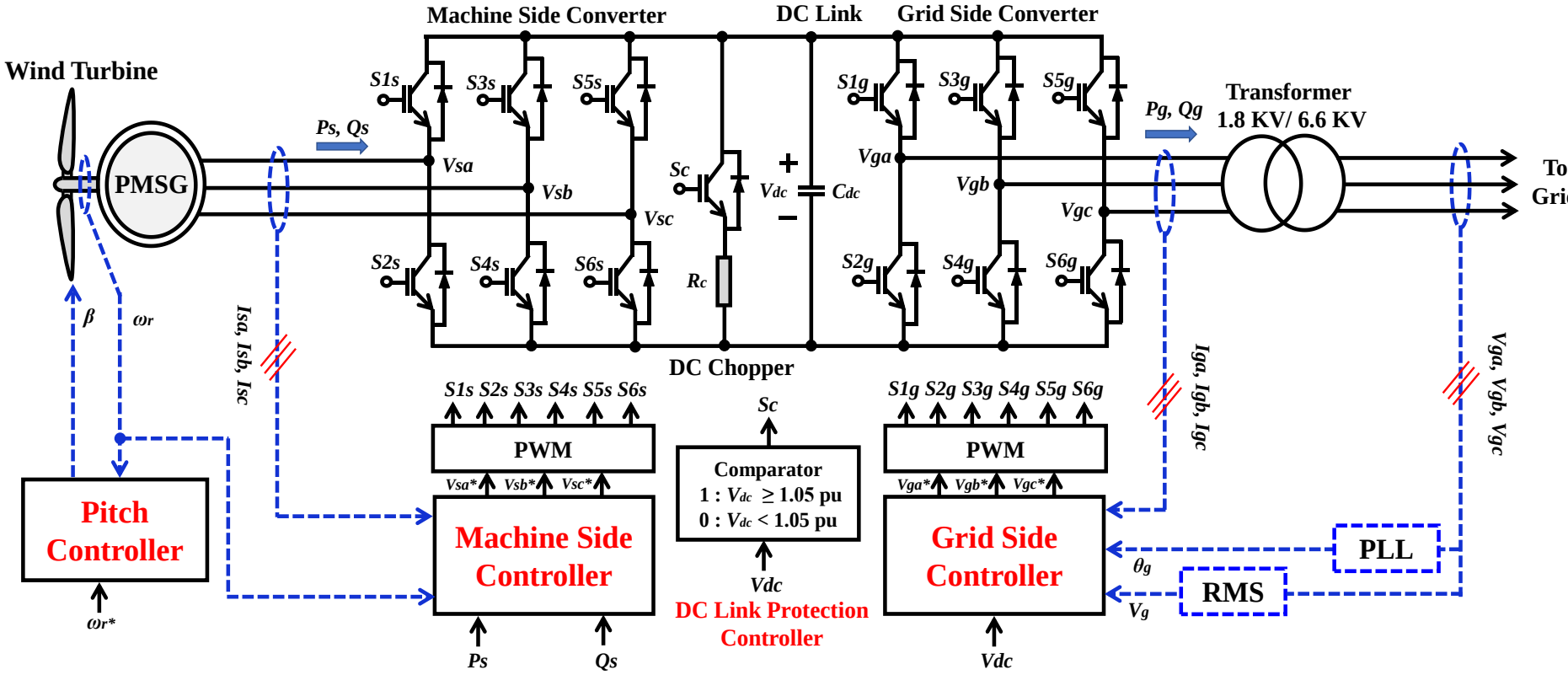


Figure 2.2: Control scheme for VSWT-PMSG.

Md. Rifat Hazari, "Stability Augmentation of Grid-Connected Wind Farm and Hybrid Power System by Variable Speed Wind Generator," PhD Thesis, Kitami Institute of technology, Japan, March 2019.

Operations of Wind Turbine

Power Control Method:

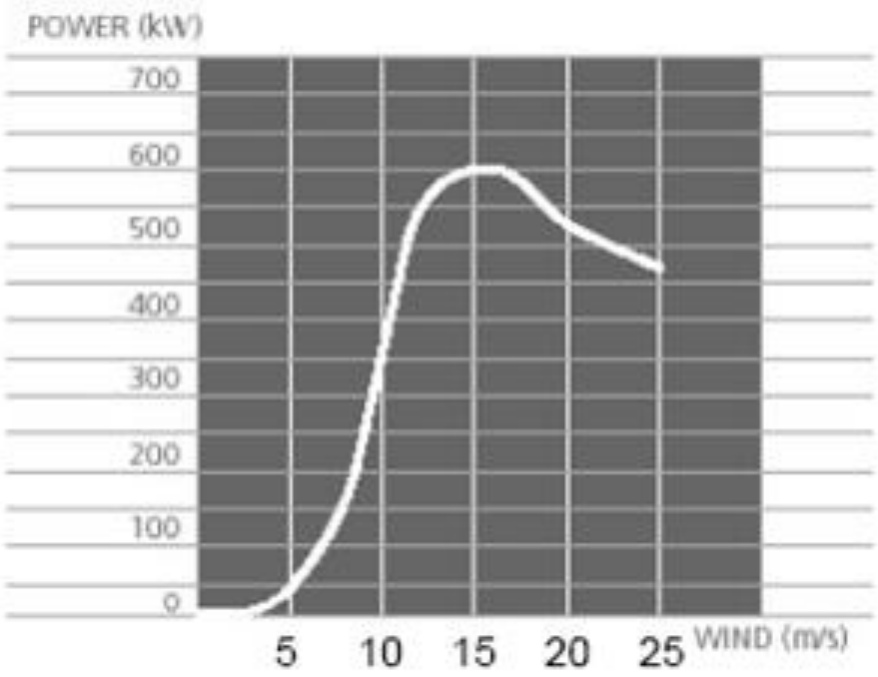
There are two main types of power control methods:

- **Stall Regulation**
- **Pitch Regulation**

Operations of Wind Turbine

Stall Regulation:

"Stall" means that the fluid flow meets the blade at very big angles of attack, the flow separates and spins on the suction side, thus increasing drag and decreasing lift forces dramatically.

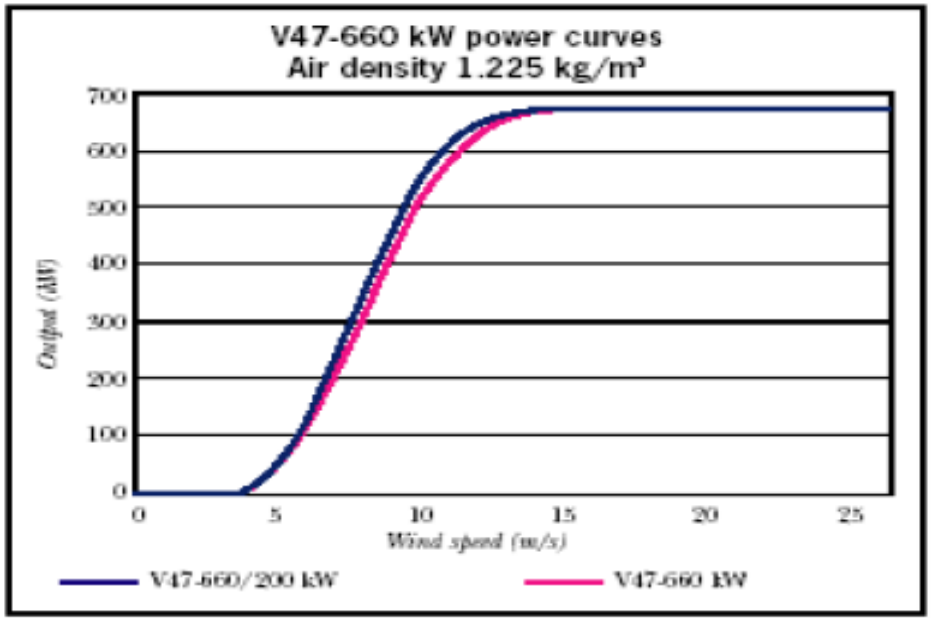


An important drawback of the stall control is the impossibility to maintain perfectly stable output.

Operations of Wind Turbine

Pitch Regulation:

Pitching means that the blade turns around its longitudinal axis, thus being able to maintain a given angle of attack (i.e. a given maximum lift force and power output) at changing wind speeds without increasing the drag forces on the blades.



Source: www.vestas.dk

Wind Turbine in Bangladesh

Bangladesh Power Development Board(BPDB)

Bangladesh Power Development Board(BPDB) has taken initiative to install 100-200 MW offshore grid connected wind power project On a Build Own Operate (BOO) basis along the coastline of Chittagong, Bangladesh.

Power Cell

The Power Cell has recommended to the government installation of a 100MW wind-based power plant in Chittagong

Wind Turbine in Bangladesh

A wind-pump set up by BCAS at Patenga, Chittagong

Wind Turbine in Bangladesh

Wind electric generator Muhuri, Feni in Bangladesh

Wind Turbine in Bangladesh

Wind Turbines of 1000 kWp Capacity Wind Battery Hybrid Power plant at Kutubdia Island, Cox's Bazar District (Bay of Bengal) in Bangladesh

Wind Turbine in Bangladesh

10kW Wind-PV hybrid power system at St. Martin Island

Reference

- Lecture notes from Department of Energy Technology, KTH, Sweden
- Wind Energy Explained: Theory, Design and Application, J. F. Manwell, Jon G. McGowan, Anthony L. Rogers, Wiley
- Wind and Solar Power Systems (2nd edition), Mukund R. Patel, CRC press, USA.
- Renewable and Efficient Electric Power Systems, Gilbert M. Masters, Wiley; 2 edition (June 24, 2013)
- Md. Rifat Hazari, "Stability Augmentation of Grid-Connected Wind Farm and Hybrid Power System by Variable Speed Wind Generator," PhD Thesis, Kitami Institute of technology, Japan, March 2019.