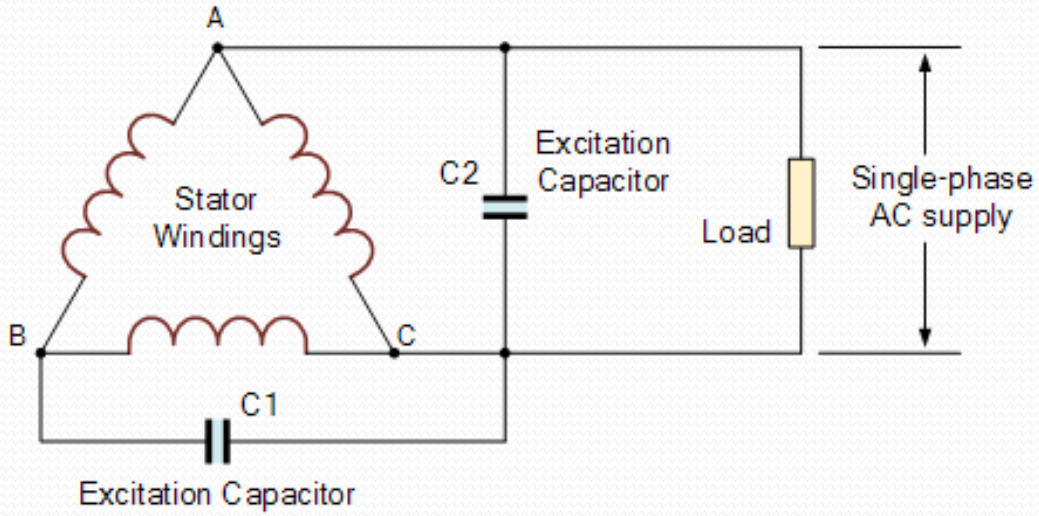
- Induction generators work well with single-phase or three-phase systems that are interconnected to the utility or as a self-excited stand alone generator for small scale wind power applications allowing for variable speed operation.
- However, induction generators require reactive excitation to operate at full power thus they are ideally suited for interconnection to the utility grid as part of an grid-tied wind power system.



Wind Turbine Generator

Types of turbine generators for wind energy

- A wind turbine is made up of two major components:
  - the rotor blade
  - the wind turbine generator (WTG)
- The electrical generator for converting the mechanical rotational power produced by the winds energy into usable electricity is at the heart of any wind power system.
- Major types of rotational electrical machines commonly used in a wind power generating systems:
  - The direct current (DC) machine, also known as a *Dynamo*
  - The alternating current (AC) synchronous machine, also known as an *Synchronous Generator*
  - The alternating current (AC) induction machine, also known as an *Asynchronous Generator*

- All these electrical machines are electromechanical devices that work on Faraday's law of electromagnetic induction.
- That is they operate through the interaction of a magnetic flux and an electric current, or flow of charge.
- As this process is reversible, the same machine can be used as a conventional electrical motor for converting the electrical power into mechanical power, or as a generator converting the mechanical power back into the electrical power.
- The electrical machine most commonly used for wind turbines applications are those acting as generators, with synchronous generators and induction generators being commonly used in larger wind turbine generators, while smaller and home made wind turbines tend to use smaller Dynamos or DC generators.

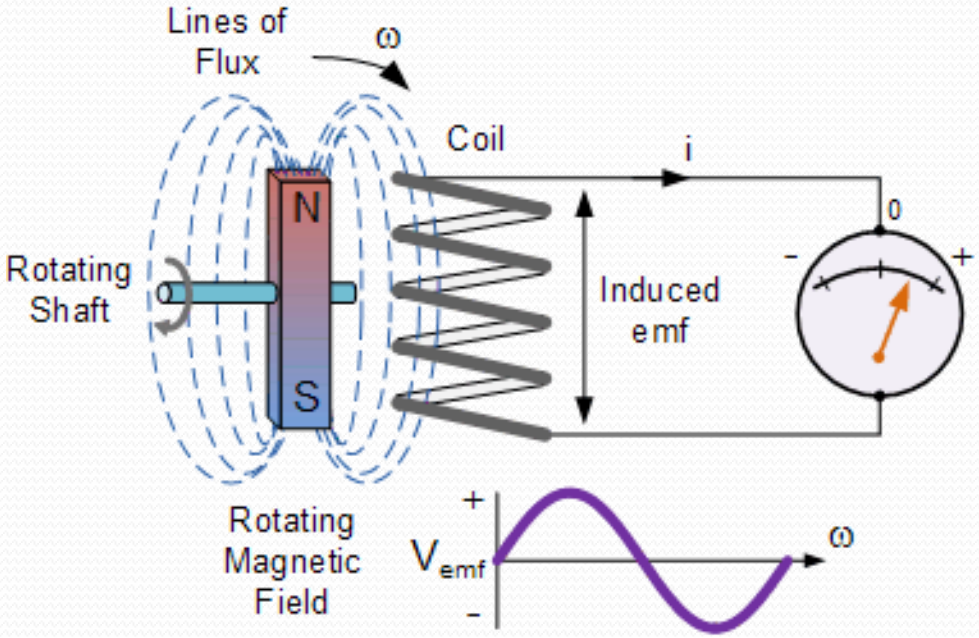
Electricity generation

- A *Wind Turbine Generator* is what makes your electricity by converting mechanical energy into electrical energy.
- The greater the "load", or electrical demand placed on the generator, the more mechanical force is required to turn the rotor.
- This is why generators come in different sizes and produce differing amounts of electricity.
- In the case of a "wind turbine generator", the harder the wind pushes, the more electrical energy can be generated.
- All electrical turbine generators work because of the effects of moving a magnetic field past an electrical coil.

Simple generator using magnetic induction

- By moving magnets past a coil of wire, an electrical current in the form of an electron flow is induced within the coil generating electricity.
- If instead of a single coil of wire, we could, instead, have many individual coils wound together on the same former, much more voltage and therefore current could be generated.

- A voltage known as an **emf (electro-motive force)** is induced in the coil of wire because the magnetic flux generated by the permanent magnet cuts it as it rotates.
- So we can see that there are three main requirements for electrical generation and these are:
  - A coil or set of conductors
  - A magnetic field system
  - Relative motion between the conductors and field



- The faster the coil of wire rotates, the greater the rate of change by which the magnetic flux is cut by the coil and the greater is the induced emf within the coil.
- Similarly, if the magnetic field is made stronger, the induced emf will increase for the same rotational speed.

  Thus: $\text{emf} \propto \Phi n$.
- Where: "Φ" is the magnetic-field flux and "n" is the speed of rotation.
- Also, the polarity of the generated voltage depends on the direction of the magnetic lines of flux and the direction of movement of the conductor.

- There are two basic types of electrical generator and alternator for that matter: the **permanent-magnet generator** and the **wound-field generator** with both types consisting of two main parts: the **Stator** and the **Rotor**.
- The stator is the "stationary" (hence its name) part of the machine and can have either a set of electrical windings producing an electromagnet or a set of permanent magnets within its design.
- The rotor is the part of the machine that "rotates". The rotor can have output coils that rotate or permanent magnets.
- Generally, generators and alternators used for wind turbine generators are defined by how they make generate their magnetism, either electromagnets or permanent magnets.

Wind Turbine Generator Output Curve

- The type of wind turbine generator required for a particular location depends upon the energy contained in the wind and the characteristics of the electrical machine itself.
- All wind turbines have certain characteristics related to wind speed.
- The generator (or alternator) will not produce output power until its rotational speed is above its cut-in wind speed where the force of the wind on the rotor blades is enough to overcome friction and the rotor blades accelerate enough for the generator to begin producing usable power.
- Above this cut-in speed, the generator should generate power proportional to the wind speed cubed until it reaches its maximum rated power output as shown.