

Homework # 7

Due: Wednesday, August 9th

Question 1. (25 points) Describe about the process of lightning phenomenon from the stage of charge accumulation in the clouds.

Question 2. (25 points) Describe about various faults that can occur in in a power system.

Question 3. (10 points) Explain the importance of renewable energy.

Question 4. (40 points) Describe in detail about the following renewable energies and how they are converted to electrical energy.

- a.) Hydro
- b.) Wind
- c.) Solar
- d.) Geothermal

1)

Friction between water, ice, and dust in the clouds leads to static and charge separation. Once enough voltage has built up from this, it can overcome the resistance of the air/clouds and create a current, ionizing the air and leading to a very sudden and rapid discharge, one way and back, sometimes multiple times in a single strike.

2)

Flashovers happen when the voltage difference between a phase and ground is enough to send enough current to ionize the air, leading to an arc between that phase and ground.

Transient faults involve an ionized path of air, so turning the power off for long enough for the ionized path to disappear should stop the fault.

Permanent faults involve a direct conducting path, so turning the power off for a short time will do nothing to solve the issue.

These can sometimes be asymmetric where all the phases fault in a balanced manner, but are far more frequently unbalanced, meaning they're not all faulting in the same way.

They can easily be described with simple notation, If it's a ground fault, you have SLG, DLG, or TLG for Single, Double, or Triple Line to Ground fault. If it doesn't involve ground, you either have a LL or LLL fault, Line to Line or Line to Line to Line.

3)

Renewable energy is important to avoid the creation of greenhouse gasses and global warming, and because we're running out of our easy to obtain supply of fossil fuels. We also hope that this leads to greater energy independence, as well as economic growth.

4)

a) Hydro

Energy is taken from flowing water to spin a turbine connected to the shaft of a generator to produce electricity. This moving water can come from either diverted moving water, or by building up a reservoir behind a dam and using it's potential energy.

b) Wind

Wind pushes on the blades of a wind turbine (with adjustable pitch and yaw) to create torque. This is only at around 20 rpm, so this is sped up by a factor of usually 80 with a gearbox so that torque can be converted by a generator into electricity. This AC will be at an unreliable frequency, so it will be transferred to the ground where it's converted to DC and back to AC at a reliable 60Hz for step up and connection to the grid.

c) Solar

Photons hit an n-type semiconductor, freeing electrons to go through the load and to the bottom contact of the p-type semiconductor. These photocells are connected into modules and arrays and generate DC voltage, which then goes through an inverter (either in micro or string configuration) to give AC which can be used or sold to the grid.

d) Geothermal

Heat from low in the earth's crust can be used in a variety of ways. Hot steam is pumped up, the heat is used, and then it's pumped back down. This heated steam will often be put through a heat exchanger to avoid using pumped water directly, before being used for either direct heating, or for electrical generation by spinning a turbine connected to a generator.