Electric Power Systems – Key Takeaways

Below you will find a number of key points from this course. Defined terms are underlined.

Week One: Basic Electricity

Electricity is a term that covers all the phenomena caused either by static electric charge or by the movement of charge (current) and the electrical and magnetic fields associated with that.

All electrical states and processes are linked to the presence of the tiny elementary particles known as an **electron**.

An **atom** was long thought to be the ultimate indivisible component of matter.

Materials that contain free electrons that are able to move with little resistance are called **conductors** and electric current can only occur in these such materials

Materials that contain very few free electrons are usually called non-conductors or **insulators**. They can conduct next to no current.

Materials that fall into the category of **semiconductors** occupy a special position between conductors and insulators. The conductivity of these materials can be altered by a process called doping, which introduces impurities into a substance that can lead either to a surplus of free electrons or a relative absence of them.

The forces exerted on one another by electric charges are related to an electric field that surrounds any charged body.

The **voltage** of the source is defined as the quotient of the work and the charge

If the polarity of an electrical energy source does not change over time, it is called a **direct current source.**

The principle of a galvanic elements involves using electro-chemical processes to generate a voltage.

A **power supply** provides power supplied from the AC network

The unit of electrical resistance, **Ohm**, is named after the German physicist Georg Simon Ohm.

A simple **electrical circuit** consists of the following components:

- Voltage source (e.g. a battery or power supply)
- Consumer or load (e.g. incandescent lamp)
- Connections between the voltage source and the load (e.g. cables/leads)
- A switch to open and close the circuit (may be omitted)

Electrical voltage is measured with a voltmeter.

The unit of frequency, **Hz**, is named Hertz after the German physicist.

Week Two: Generation, Transmission, & Distribution

Points inside a network where two or more lines meet are called **buses**.

The spatial arrangement of the facilities necessary for measurements, monitoring, protection and ancillary tasks is known as **switchgear**.

A **transformer** is a device that transforms AC voltage from high to low or vice versa.

A **substation** is comprised of transformers and switchgears.

An **electricity generator** is a device that converts a form of energy into electricity.

A **thermal generator** creates electricity by using heat from the burning of fuels or nuclear energy to create steam which turns a turbine, which rotates a generator shaft through opposing magnetic fields.

A **turbine** converts the kinetic energy of a moving fluid (liquid or gas) to mechanical energy

Power typically flows from a generator, along the transmission grid to a substation where it is transformed, or stepped down, to a lower voltage for distribution.

Electric power distribution is the final stage in the delivery of electric power; it carries electricity from the transmission system to individual consumers.

Radial distribution networks are systems with a single power source for a group of distribution customers.

Interconnected distribution networks are composed of multiple connections to power supply sources.

A **distribution transformer** steps the primary distribution power down to a low-voltage secondary circuit for residential customers.

Once electricity reaches its final destination, it runs through a **meter** for billing purposes

Week Three: System Design & Switching

The **switchgear** components are:

1. Busbars
2. Switches
3. Circuit breakers
4. Current and voltage transformers
5. Surge arresters
6. Grounding switches

When switching device disconnects a circuit under load or even at no load but with voltage present, an arc will appear between the contacts which is very dangerous for personnel and equipment and must be extinguished.

Circuit breakers are available for low-voltage, medium-voltage, and high-voltage applications.

Disconnect switches (or disconnectors) are used to ensure that an electrical circuit is completely de-energized for service or maintenance.

When the disconnect switch has the additional ability to ground the isolated circuit thereby providing additional safety, it is called a **grounding switch.**

Week Four: Renewable Energy & Smart Grid Technologies

Since 1982, growth in peak demand for electricity – driven by population growth, bigger houses, bigger TVs, more air conditioners and more computers – has exceeded transmission growth by almost 25% every year.

Five massive blackouts over the past 40 years, three of which in the past nine years.

If the grid were just 5% more efficient, the energy savings would equate to permanently eliminating the fuel and greenhouse gas emissions from 53 million cars.

United States accounts for only 4% of the world's population and produces 25% of its greenhouse gases. Half of the U.S. electricity is produced by burning coal.

Germany is leading the world in the development and implementation of photo-voltaic solar power.

The European Union has an aggressive "Smart Grids" agenda, a major component of which has buildings functioning as power plants.

The **Smart Grid** represents transformation from a centralized, producer-controlled network to one that is less centralized and more consumer-interactive.

Smart Grid technologies that are already in place:

- Advanced Metering Infrastructure
- Visualization Technology
- Phasor Measurement Units
- Distributed Generation
- Peak Demand
- Smart Meter

The Smart Grid's single biggest potential in delivering carbon savings is in providing cost-effective and increasingly clean energy for plug-in electric vehicles

If we do nothing, an environmental study shows that U.S. carbon emissions are expected to rise from 1700 million tons of carbon per year today to 2300 million tons of carbon by the year 2030.

The same study shows that utilities, through implementation of energy efficiency programs and use of renewable energy sources, could reduce the carbon output to below 1,000 million tons of carbon by 2030.

Wind energy is mainly used to generate electricity

Solar photovoltaic (PV) devices, or solar cells, change sunlight directly into electricity.

Solar thermal energy systems:

- heat water for use in homes, buildings, or swimming pools
- heat the inside of homes, greenhouses, and other buildings
- heat fluids to high temperatures in solar thermal power plants