



# Overview of the Electric Power Industry

An Online Continuing Education Course for Engineers

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# Overview of the Electric Power Industry

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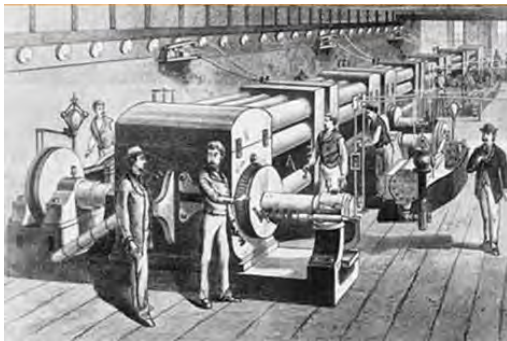
## Introduction

The 20<sup>th</sup> Century was dominated by the development of centralized electric power systems that improved the productivity and positively impacted every facet of civilization from the electrification of streetlights, to manufacturing plants, and to farms across America. It spurred the development of innumerable products to improve the quality and enjoyment of life.

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*“Electrification is the greatest technical achievement of the 20th Century” – National Academy of Engineering*

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In 1882 Thomas Edison began operation of the first central generating station to power streetlights in New York City. The Pearl Street Station used a coal-fired steam engine to produce direct current (DC) to power streetlights in the city. Other uses quickly followed including electric streetcar and electric power elevators. Because low voltage direct current cannot be transmitted long distances, numerous small electric plants sprung up in New York and other large cities.

In 1886, George Westinghouse introduced alternating current (AC) power plants. Alternating current is more efficient because it can easily increase low-voltage generation to a higher voltage for long-distance transmission, and then back to low-voltage distribution for the end-user.

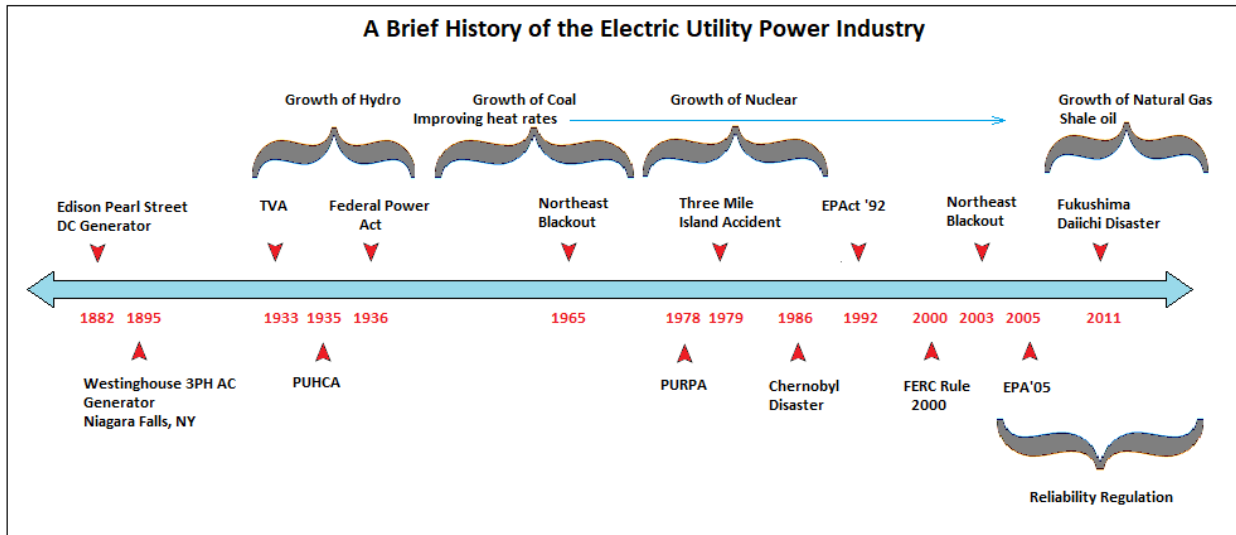


Fierce competition developed between Thomas Edison and George Westinghouse for the control of how electric power would be generated and distributed in the United States. Ultimately the marketplace selected Westinghouse’s multi-phase AC power technology for the distribution of electric power.

The period from the late 1890s through the late 1920s saw the rapid expansion of electric power and the consolidation of many of the smaller companies into large holding companies. More efficient generator plants came into production, and the cost of power declined with each new generation.

As the industry grew, regulation increased, and the Federal Power Act was created in 1936 to regulate the interstate commerce of electric power.

Figure 1 shows a brief history of the electric utility power industry from 1882 until recent history.



**Figure 1**

This course will explain some of the basic terms related to electric power, how the electricity market is structure and specifics about the three components of the electric power industry: Generation, Transmission, and Distribution.

## Chapter 1 - Electricity 101

This chapter explains some of the common technical terms related to the electric power industry. This includes terms such as AC power, DC power, energy, demand, voltage current, frequency, etc.

### AC versus DC

Thomas Edison began the electric power distribution concept using DC current. Any battery is a direct current (DC) source. It is easy to generate and relatively safe. However, it is difficult to convert from one voltage to another and therefore it is difficult to transmit long distances.



In contrast, alternating current (AC) – like that provided by the outlets in your home - is complicated to generate and even very small AC currents can be fatal to humans. The benefit is that it is easy to convert from one voltage to another (either to step the voltage up or to step it down) and it is easy to transmit very long distances.

### Voltage, Current, Energy, and Power

Voltage and current are best explained by the use of a water analogy. Consider the following drawing in Figure 2.

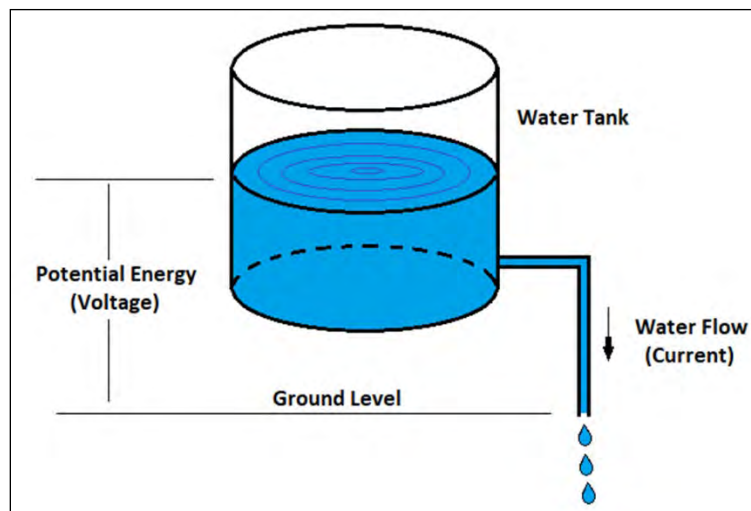


Figure 2

Like water contained in a water tank, voltage is potential energy or the pressure to push the current along. Current is analogous to the water flow from the water tank. Voltage is measured in *volts*, and current is measured in *amperes* or *amps*. The voltage (pressure) provides the push to move the electric current. To move more water requires a bigger pipe and to move more current requires a bigger conductor (wire). The amount of water delivered (gallons) is similar to the amount of electric energy delivered (kilowatt-hours, kWh) and the demand for water is measured in gallons per minute whereas electric demand is measured in kilowatts.

Typical voltages found in electric power systems include:

- Generation: 15,000 volts (15kV)
- Delivery - 230,000 volts (230 kV)
- Town circuits - 12,000 volts (12 kV)
- Households - 120/240 volts

Utilities are required to maintain voltages within acceptable limits as defined by the American National Standards Institute (ANSI). See Figure 3 for acceptable voltage limits.

Voltage Regulation Requirements (ANSI C84.1)				
Base	Range A		Range B	
	+5%	-5%	+5.8%	-8.3%
120 V	126	114	127	110
480 V	504	456	508	440

Figure 3

Electric power is called *demand* and is the product of voltage and current. For instance, an electric hair dryer may be rated to consume 12.5 amps and 120 volts. Therefore, the power demanded is,

$$\text{Power} = \text{Volts} * \text{Current}$$

$$\text{Power} = 120 * 12.5$$

$$\text{Power} = 1,500 \text{ watts, or } 1.5 \text{ kW}$$



Demand is measured in watts (w), or thousands of watts (kilowatts, kW), or millions of watts (megawatts (MW)).

A typical residential home with air-conditioning may have an average demand of 4 kW and a peak demand of 9-12 kW.

Electric energy is a measure of the power consumed and is measured in watthours (Wh), thousands of watthours (kilowatt-hours, kWh), or millions of watthours (megawatt-hours, MWh).

Continuing with the hairdryer example, if it is used continuously for three hours the energy consumption will be:

Energy = 1

Energy = 3

Energy = 4.

At a typical energy rate of \$0.10 per kWh, the cost of running the dryer is \$0.40.

### AC Frequency

By definition, alternating current (AC) looks like a sine wave that alternates between positive and negative values. In the United States, the frequency of AC is 60 Hz. In Europe, the frequency is 50 Hz. Figure 4 shows an AC waveform.

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