

3 | Power System Overview

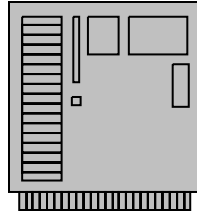
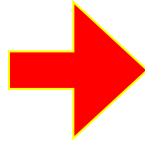
- Generating Station
- Transmission System
- Transmission Substation
- Sub transmission System
- Distribution Substation
- Distribution System

Course Outline

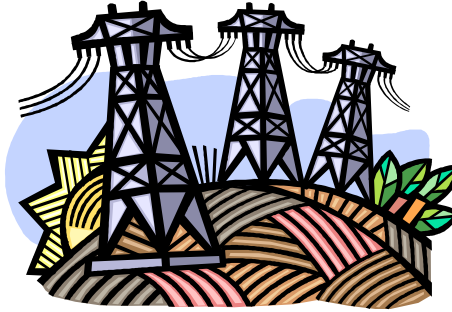
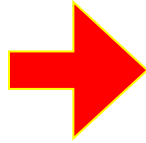
1. Introduction to WECC
2. Fundamentals of Electricity
3. Power System Overview
4. Principles of Generation
5. Substation Overview
6. Transformers
7. Power Transmission
8. System Protection
9. Principles of System Operation



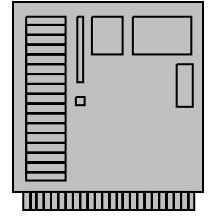
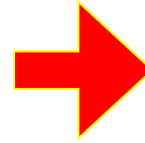
Generator



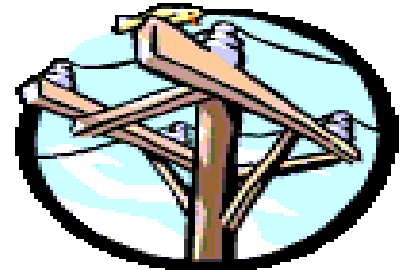
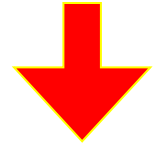
Step-up
Transformer



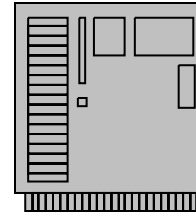
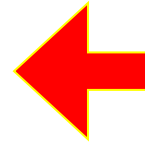
Transmission System



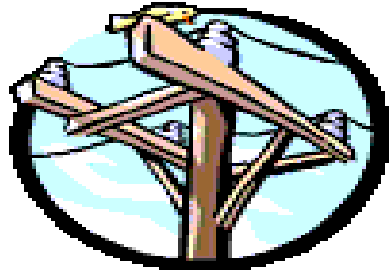
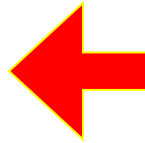
Transmission
Substation



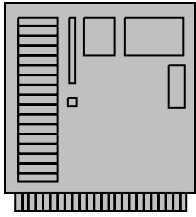
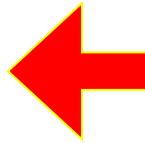
Sub Transmission
System



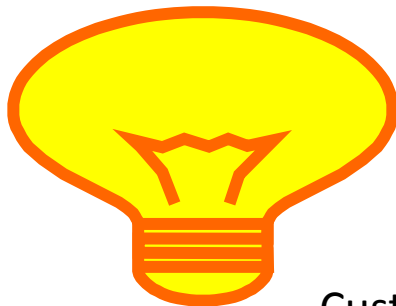
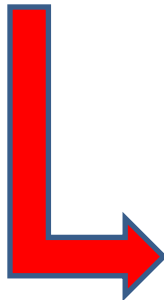
Distribution
Substation



Distribution
System



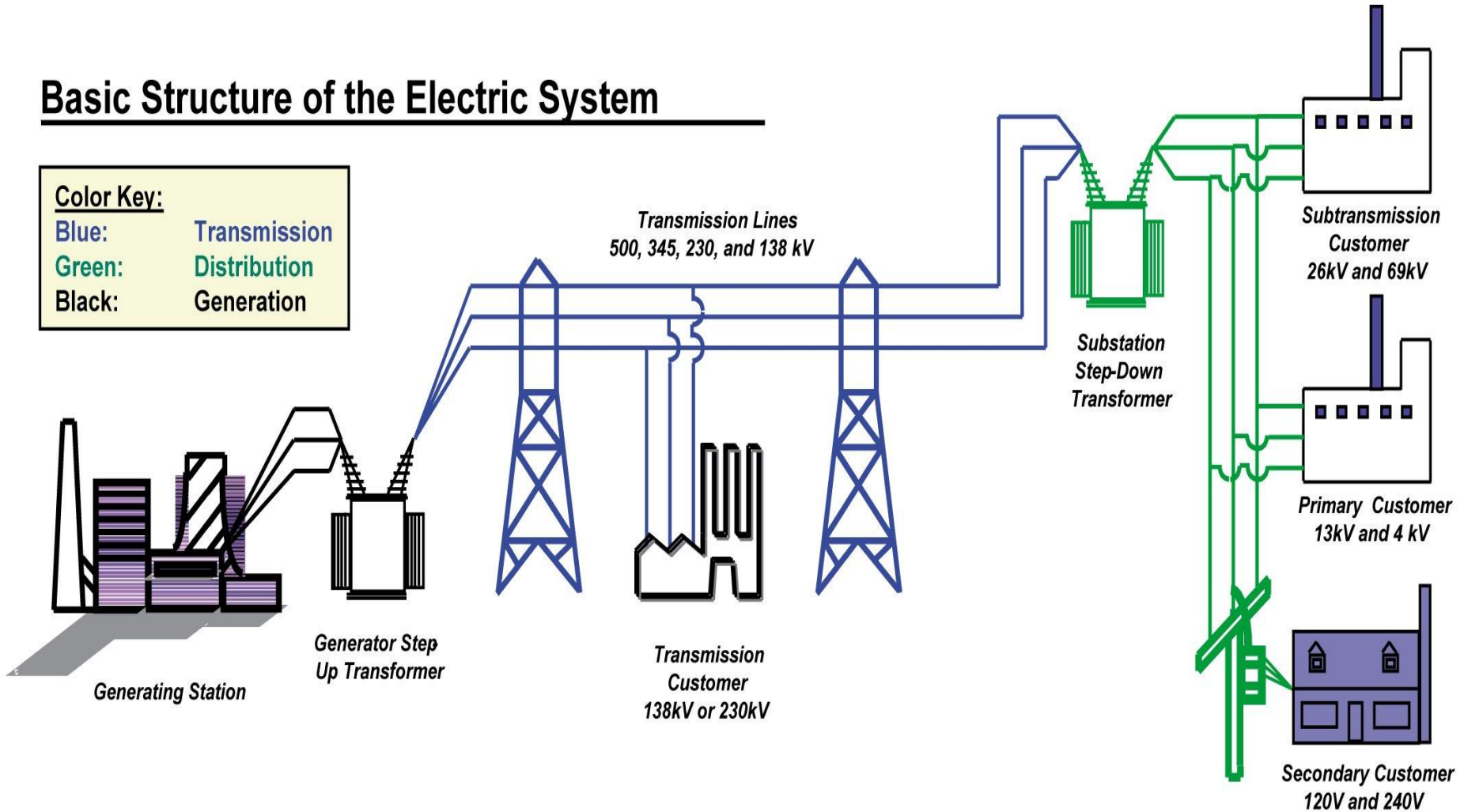
Step-down
Transformer



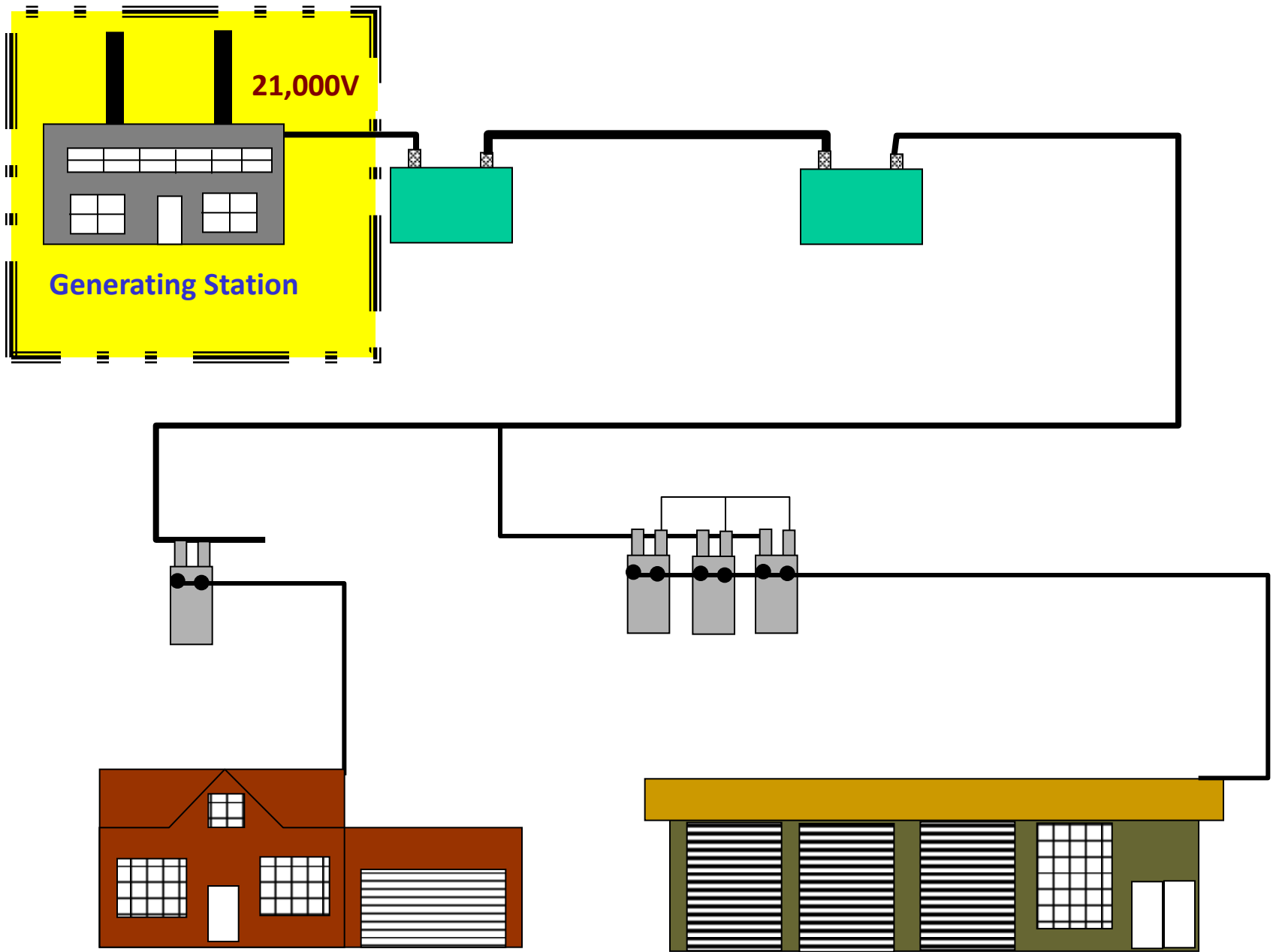
Customer

The Power Grid

Basic Structure of the Electric System



Generating Station



Generating Station

21,000V

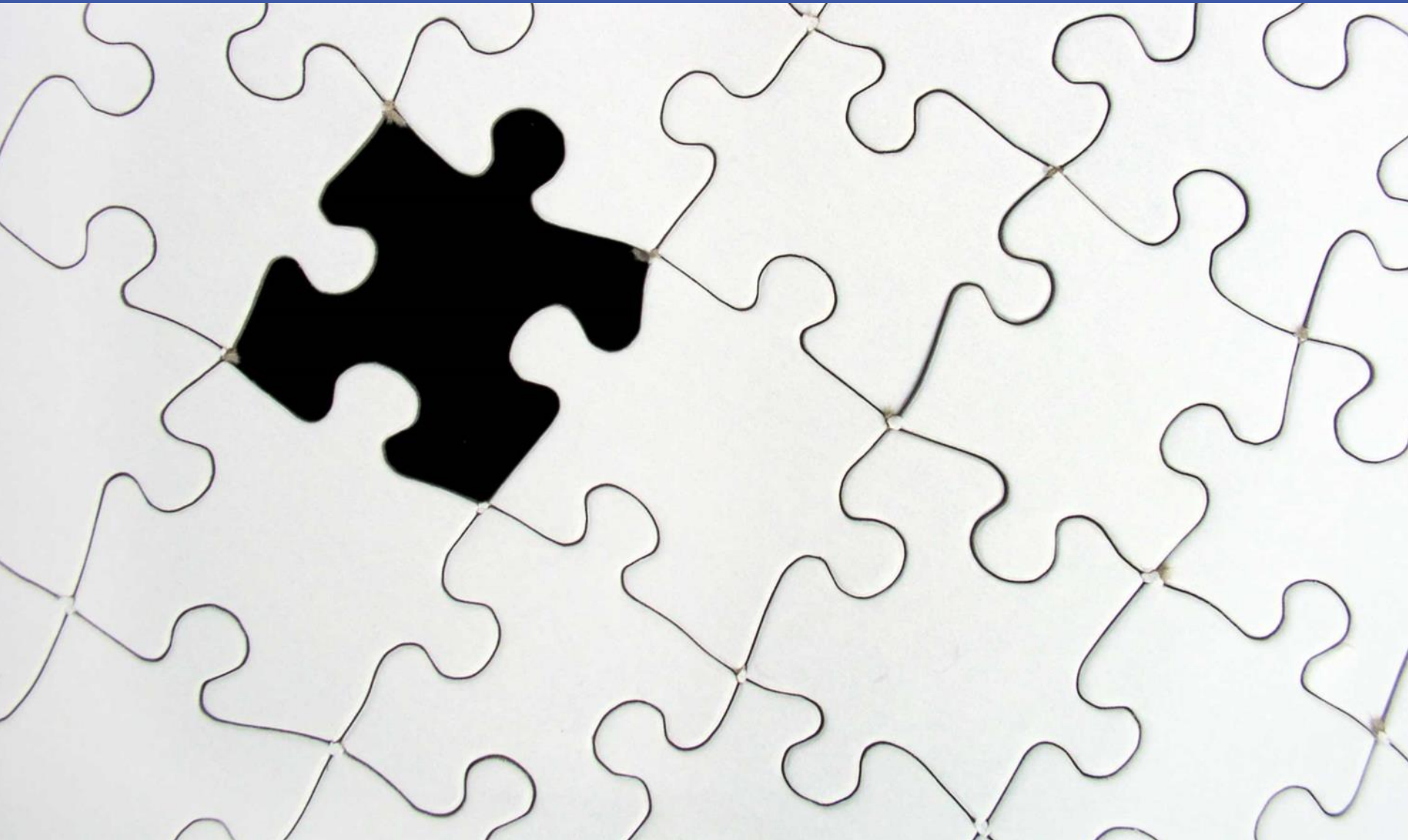
Residential Customer

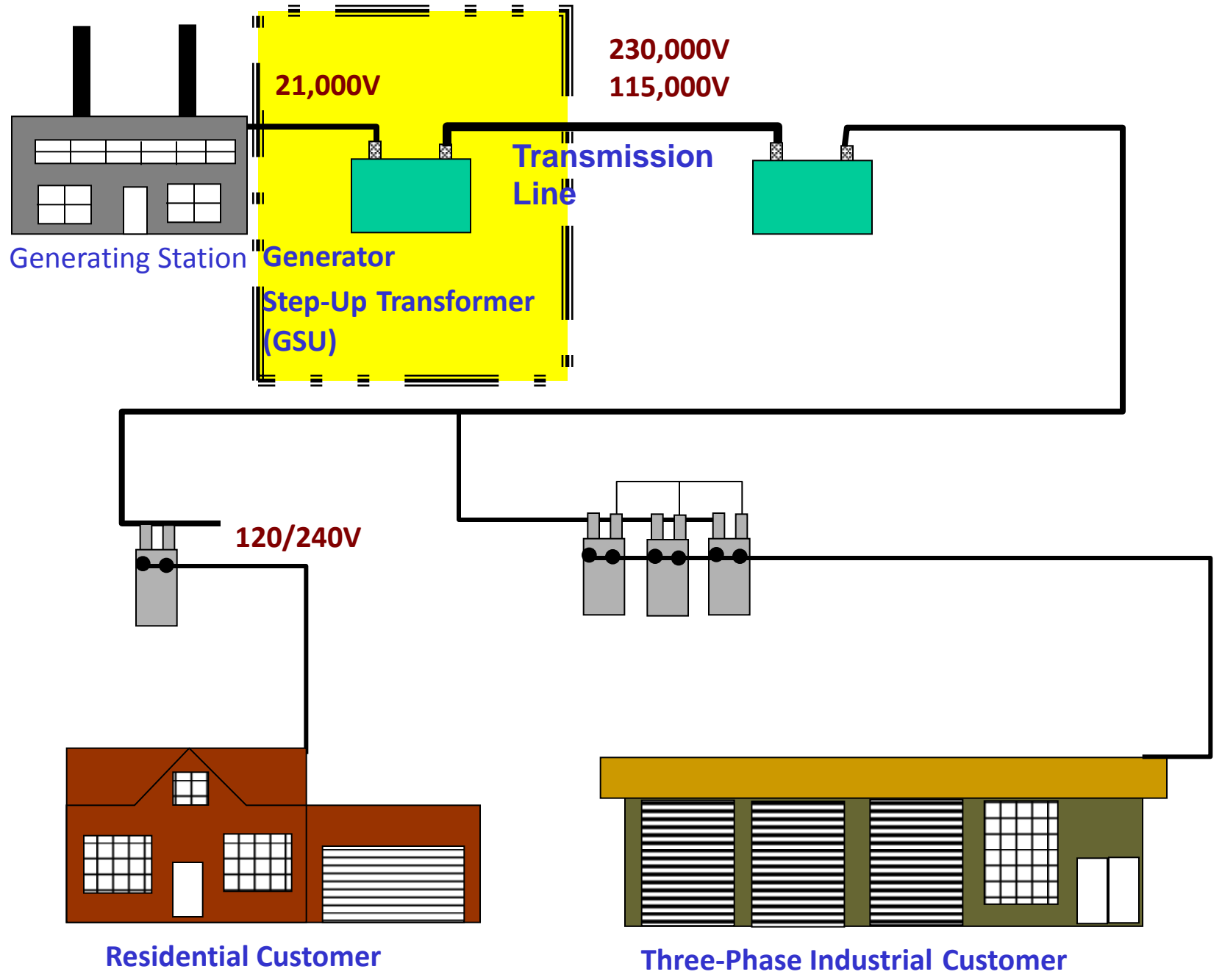
Three-Phase Industrial Customer



Generating Station Step Up Transformer

RECAP: Putting It All Together

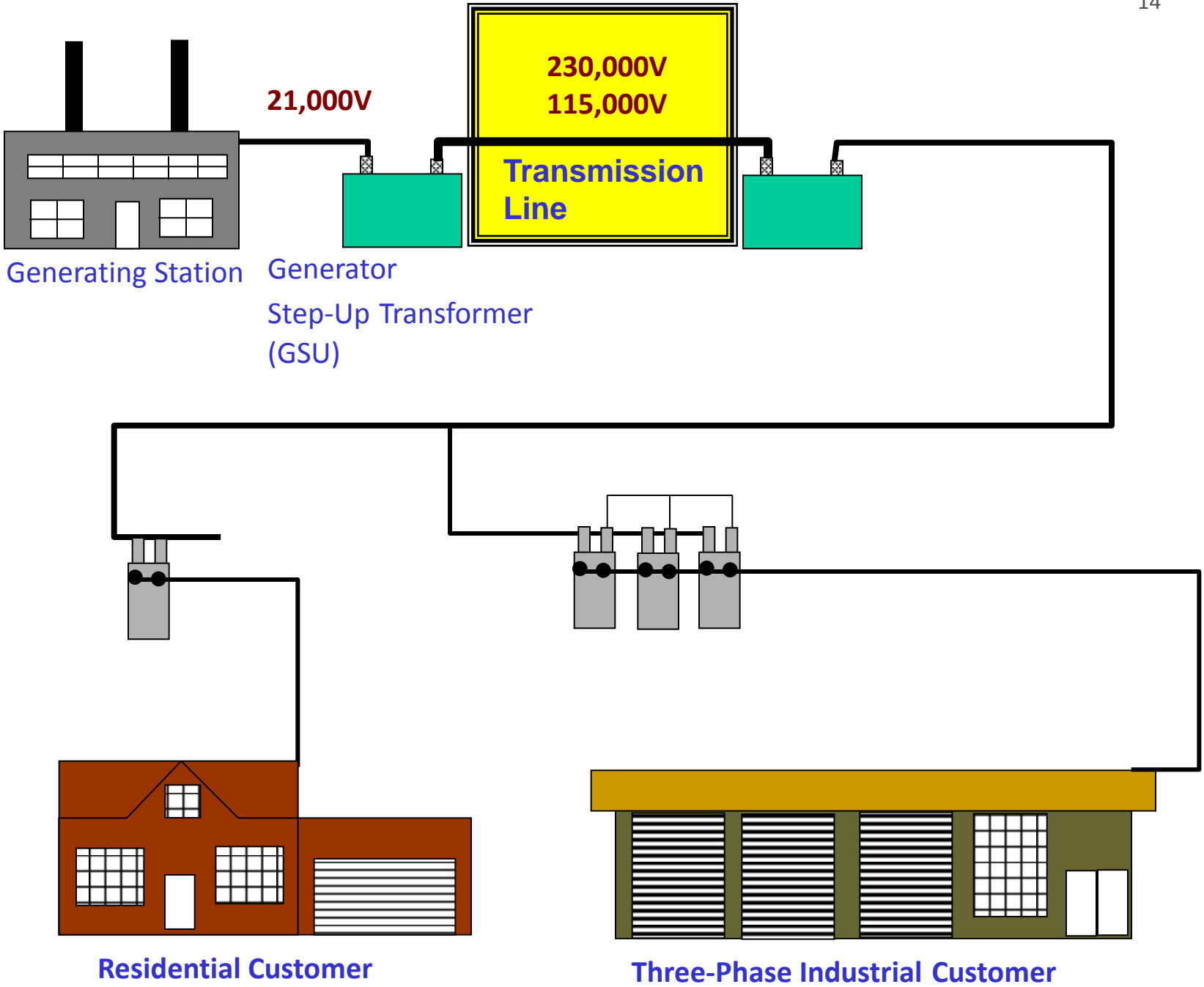








Transmission System





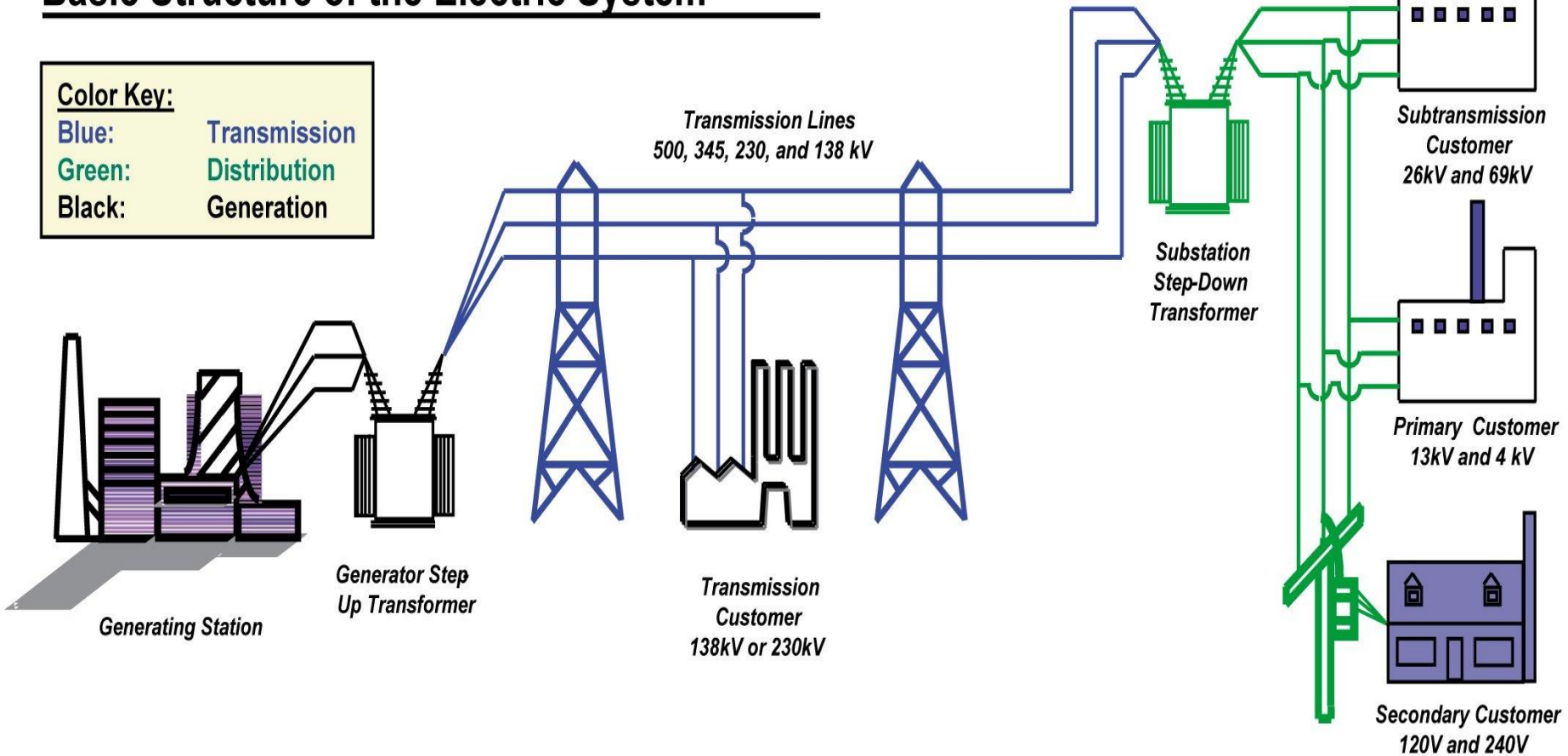
Transmission System

What is Transmission?

- “Highway” for bulk power
- High design voltages
- High design reliability

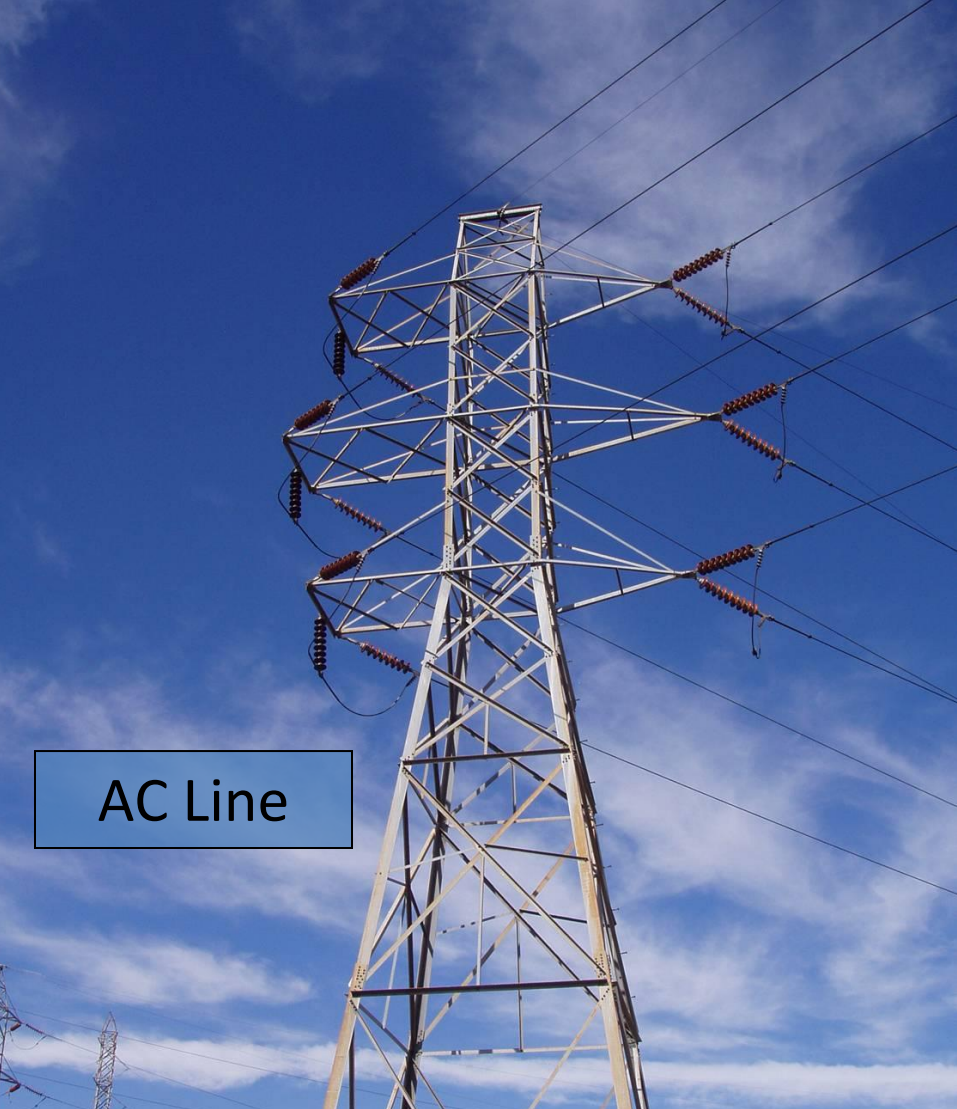
Transmission System

Basic Structure of the Electric System

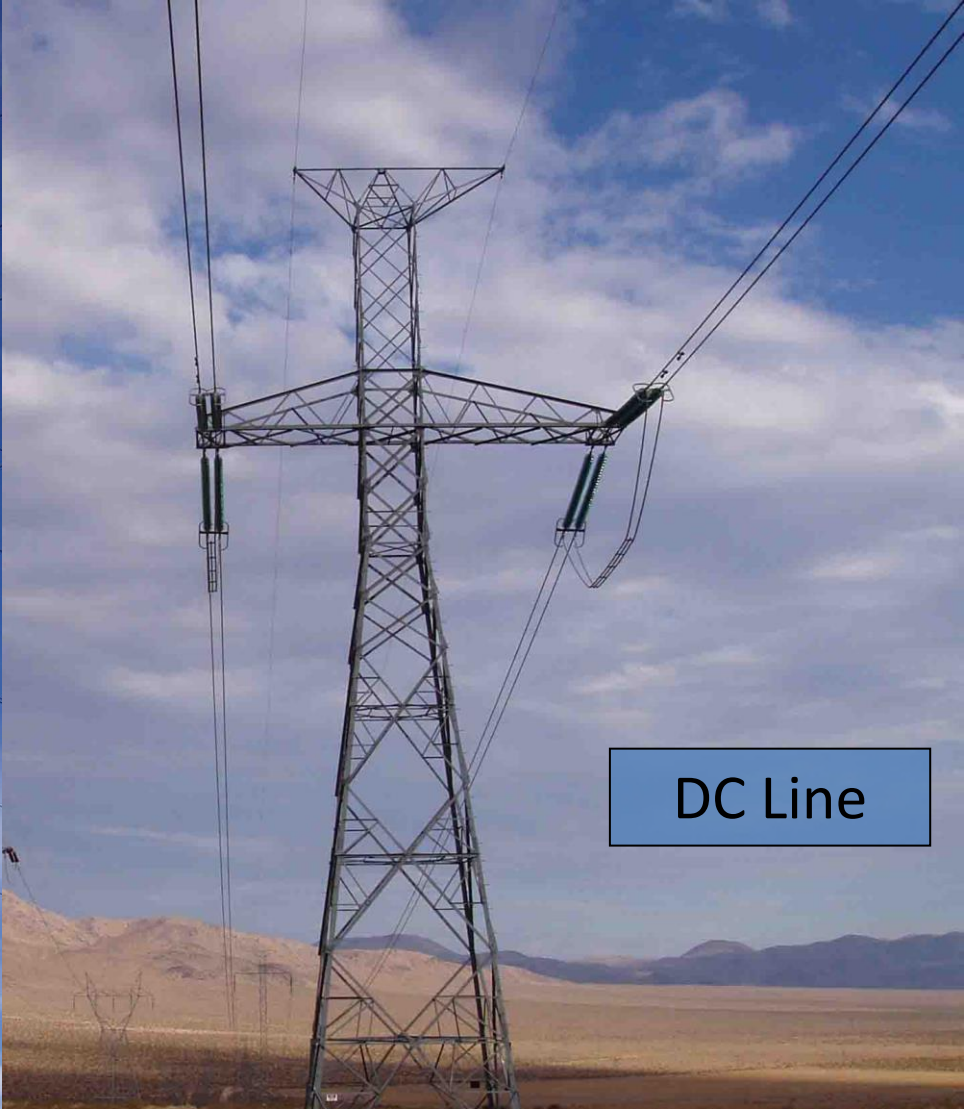


Transmission System Components

- Lines & towers
- Power Transformers
- Circuit breakers, switches, buswork
- Capacitors, reactors
- Control, metering, & protective equipment



AC Line



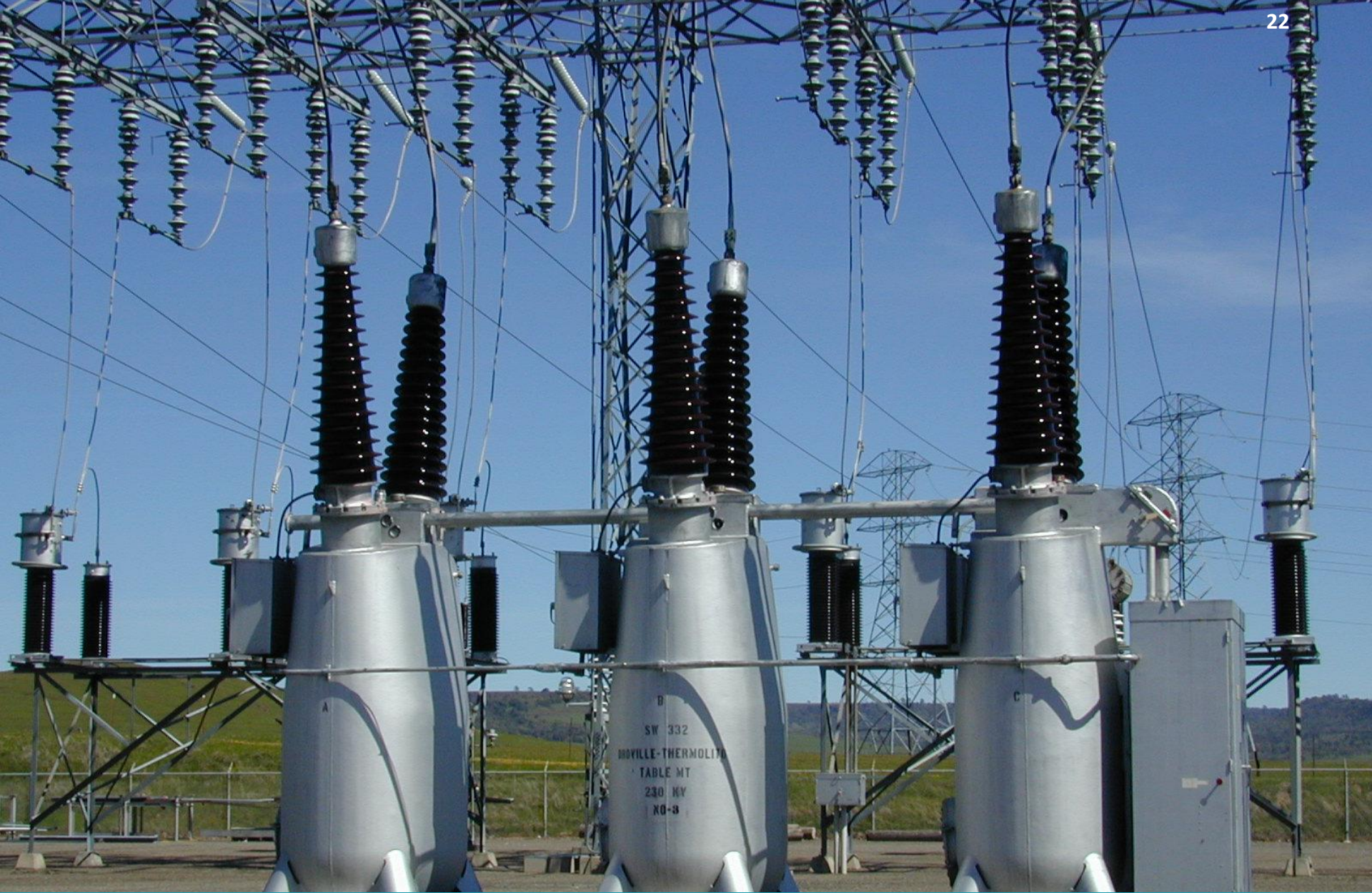
DC Line

Transmission Lines





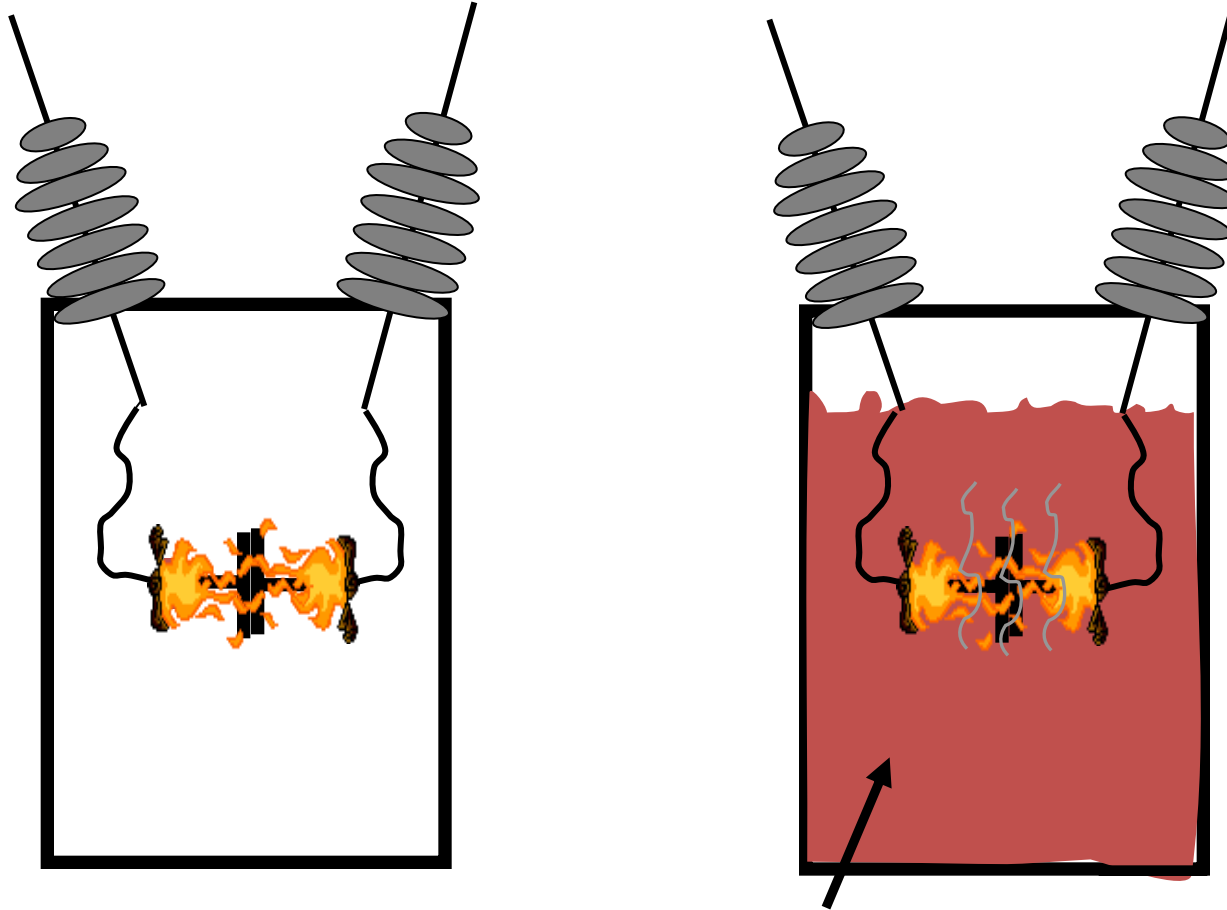




Oil-filled Circuit Breaker

Transmission System

How an Oil Breaker Works



Insulating Oil

Transmission System

Three Circuits and Three Breakers





SF₆ Gas-filled Circuit Breaker



Circuit Switcher

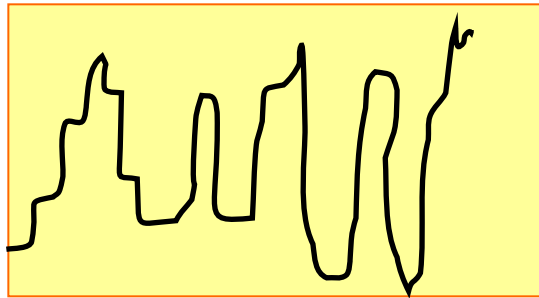
Instrument Transformers

Current and Voltage

Actual circuit

1000 amps

0 amps

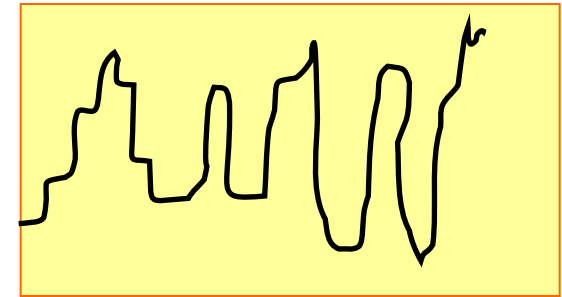


time

CT circuit

5 amps

0 amps

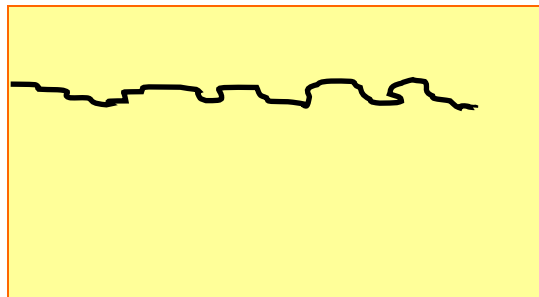


time

Actual circuit

500 kv

0 kv

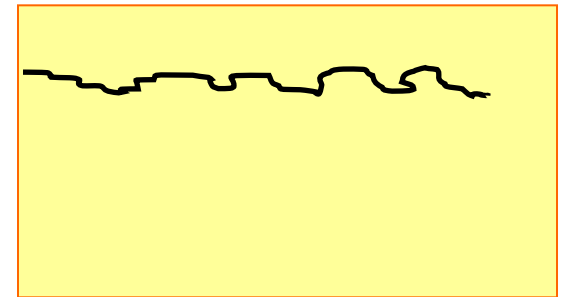


time

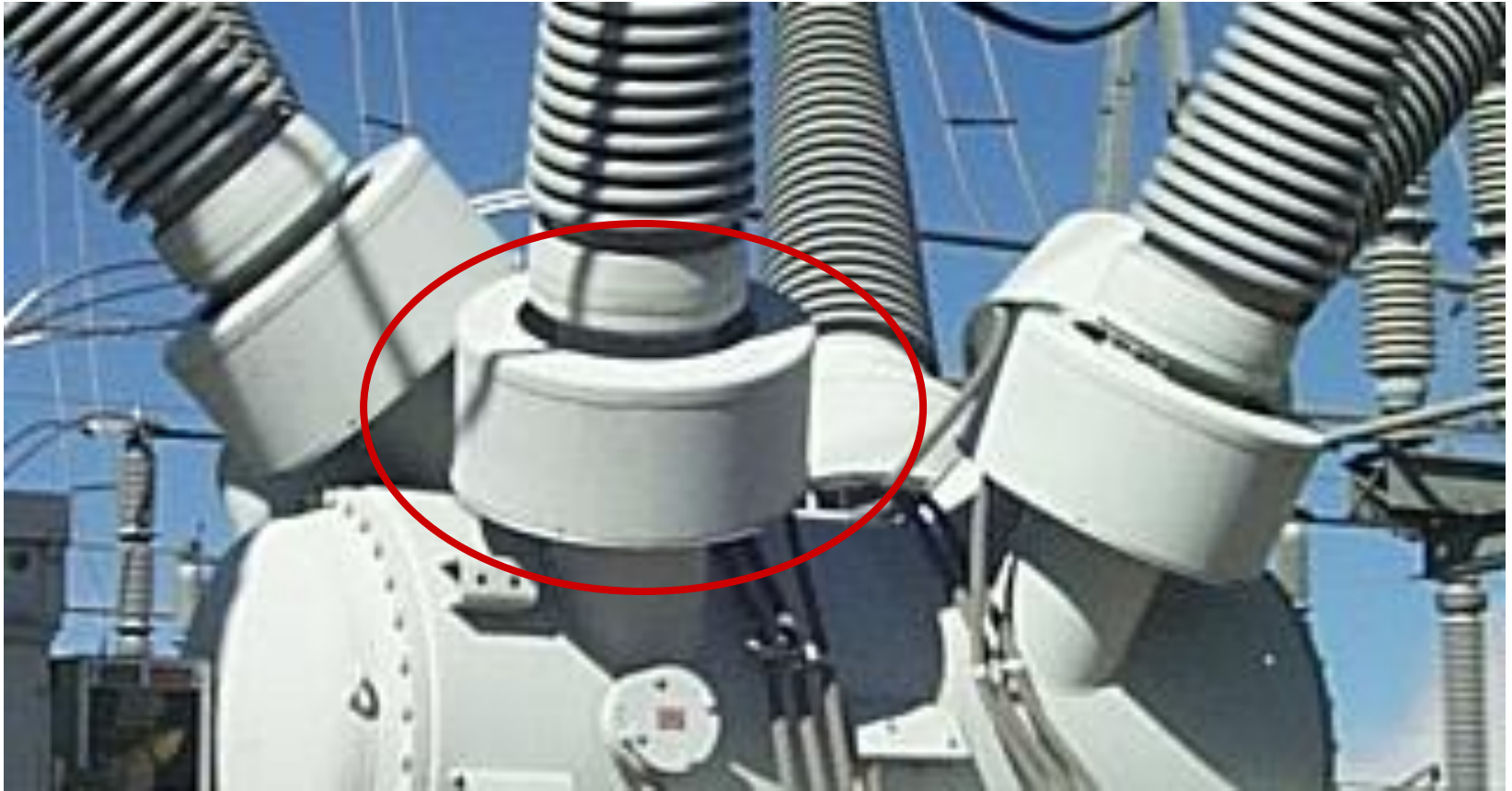
VT circuit

120 volts

0 volts



time



Current-Measuring Transformer (CT)



Voltage Measuring Transformers (VT)

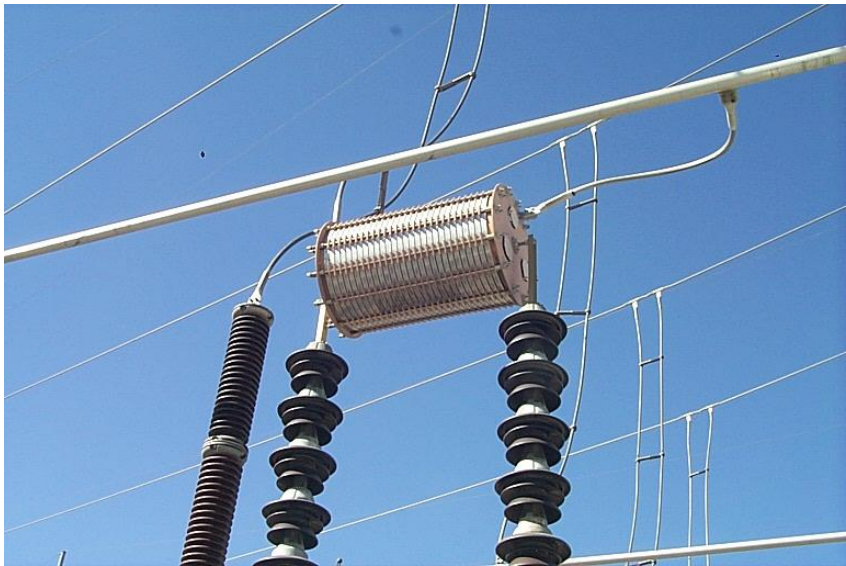




Protective Relays

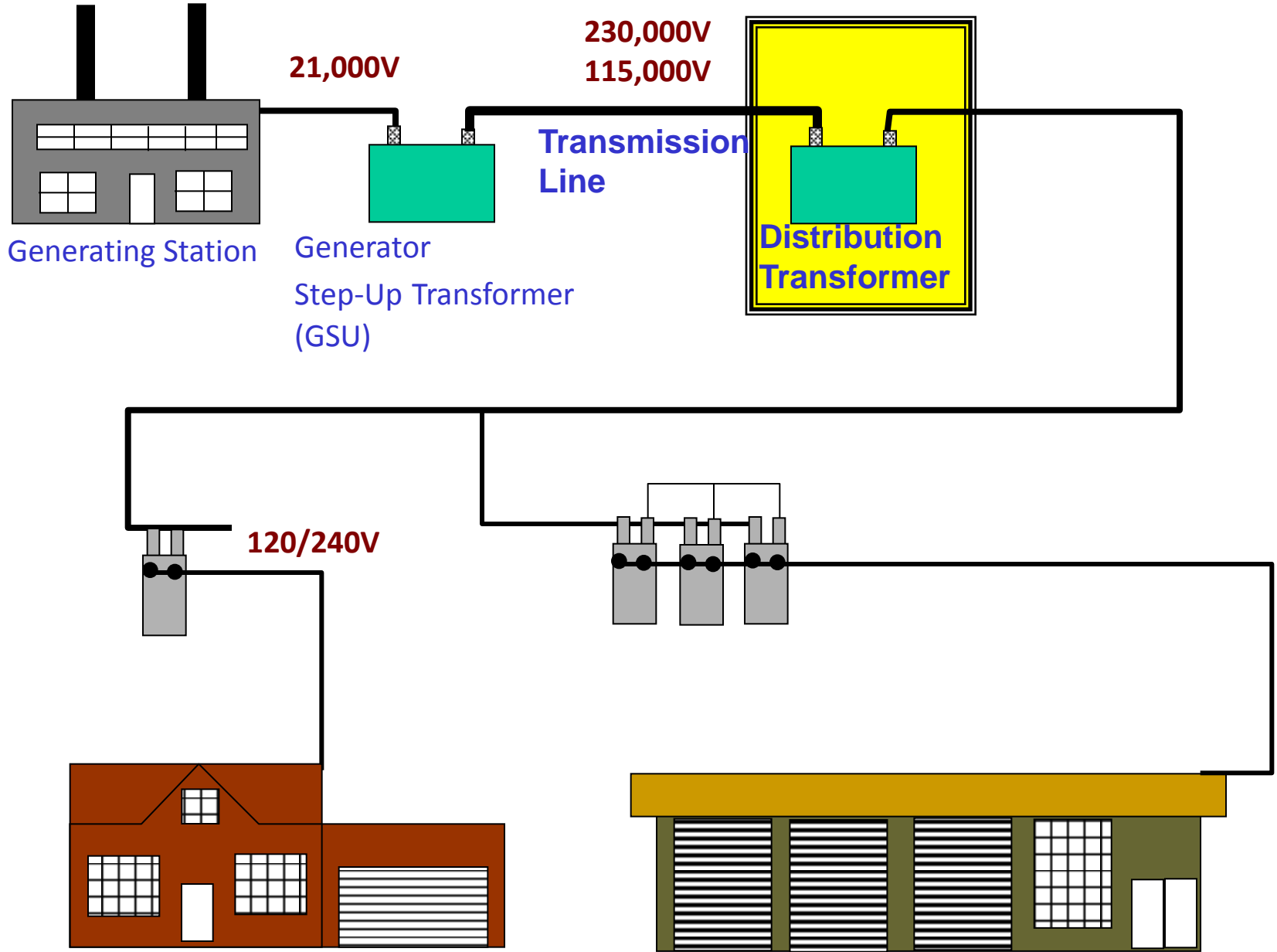


Communications Equipment





Transmission Substation Step Down Transformer



Generating Station

Generator
Step-Up Transformer
(GSU)

Transmission
Line

Distribution
Transformer

120/240V

Residential Customer

Three-Phase Industrial Customer

Transmission Substation

- **Definition: Extra High Voltage (EHV)**
 - Extra High Voltage (EHV) is the term given to transmission voltages above 230 kV.
 - For example, lines operating at 345 kV, 500 kV and 765 kV are EHV lines.
- **Definition: Ultra High Voltage (UHV)**
 - Ultra High Voltage (UHV) is the term given to transmission lines above 800 kV. The use of UHV lines is still somewhat experimental in North America.
- **Definition: High Voltage Direct Current (HVDC)**
 - In addition to the AC lines described above, some utilities use High Voltage Direct Current (HVDC) transmission lines with voltages up to 1500 kV pole-to-pole.

Transmission Substation

Definition: Switching Station

- Some transmission substations, called ***switching stations, do not contain*** transformers. Rather, they contain only the equipment necessary to sectionalize the transmission system.
- A switching station switches transmission circuits in and out of service when necessary for maintenance or to isolate a problem area.



Switching Station



Power Transformer

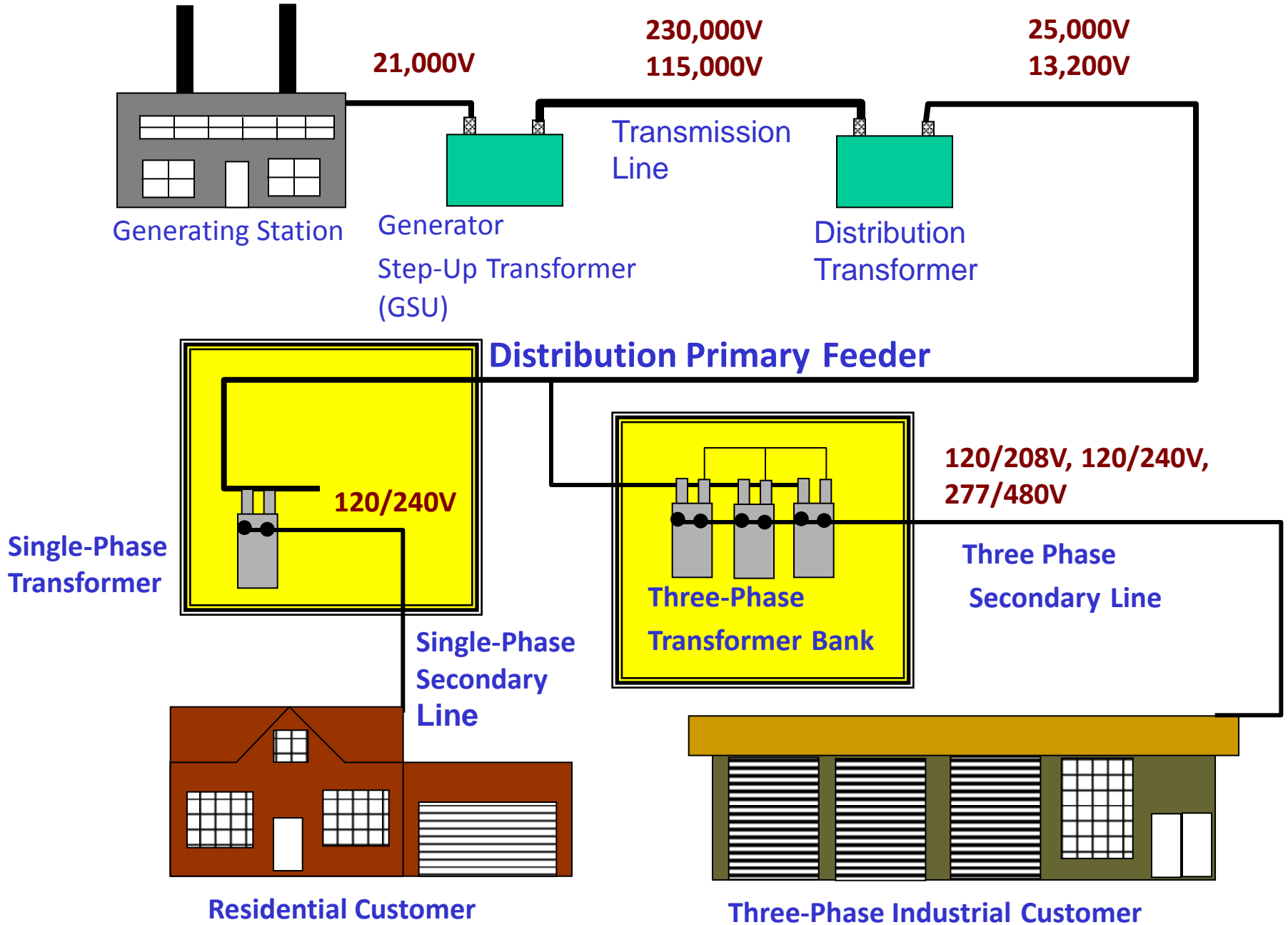




Power Transformer



Sub Transmission System and Distribution Substation



Sub Transmission System

- A subtransmission facility serves as an intermediate point between the transmission system and the distribution system that supplies the electricity to customers
- Lower voltage typically ranging between 46kV and 229kV
- Lower voltage subtransmission lines are often desirable because the wide "right-of-ways" (land areas through which the transmission lines pass) needed by higher voltage transmission lines may be unavailable in more heavily-populated areas
- Subtransmission lines do not have the same right of way requirements as transmission lines

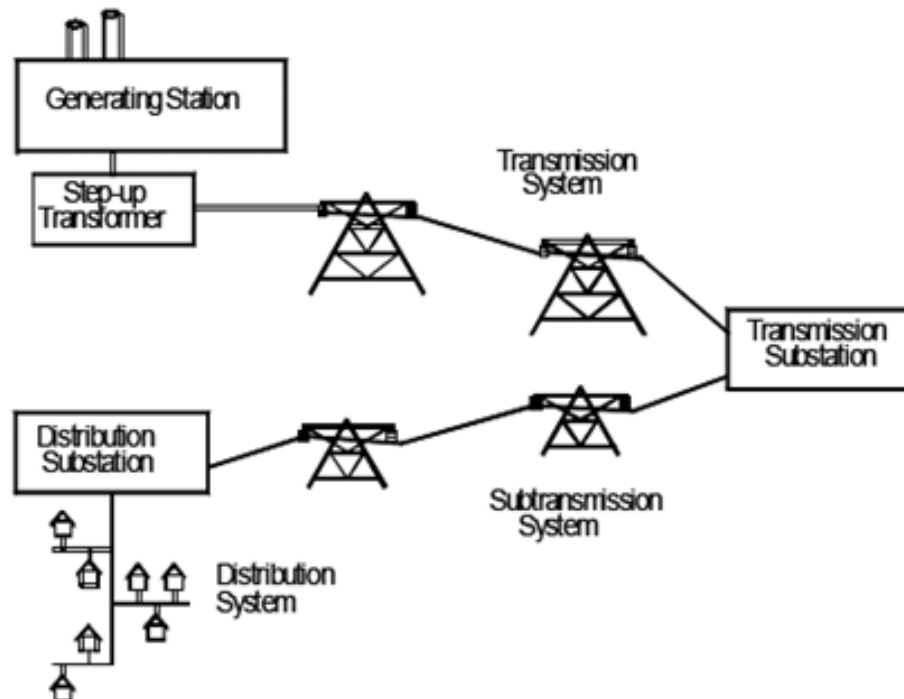
Distribution Substation

- A distribution substation energizes the distribution system that supplies power to customers
- Distribution substations contain power transformers that step down the high transmission or subtransmission line voltage to the primary distribution voltage. Most utilities operate their distribution system between 4 kV and 34.5 kV
- Circuit breakers for switching individual distribution circuits are typically installed at these stations. Utilities use circuit breakers to de-energize and re-energize individual distribution circuits that are faulty or require maintenance

Distribution System

Distribution System

A distribution system is the final step to deliver power to customers.



Distribution System

Distribution Feeders

- Distribution substations supply power to the primary distribution circuits, called distribution feeders
- Typically energized between 4 kV and 34.5 kV
- Carry power from the distribution substations to reach the customers
- Overhead wires supported by utility poles are the most common means to support the distribution feeders. Underground cables may also be used

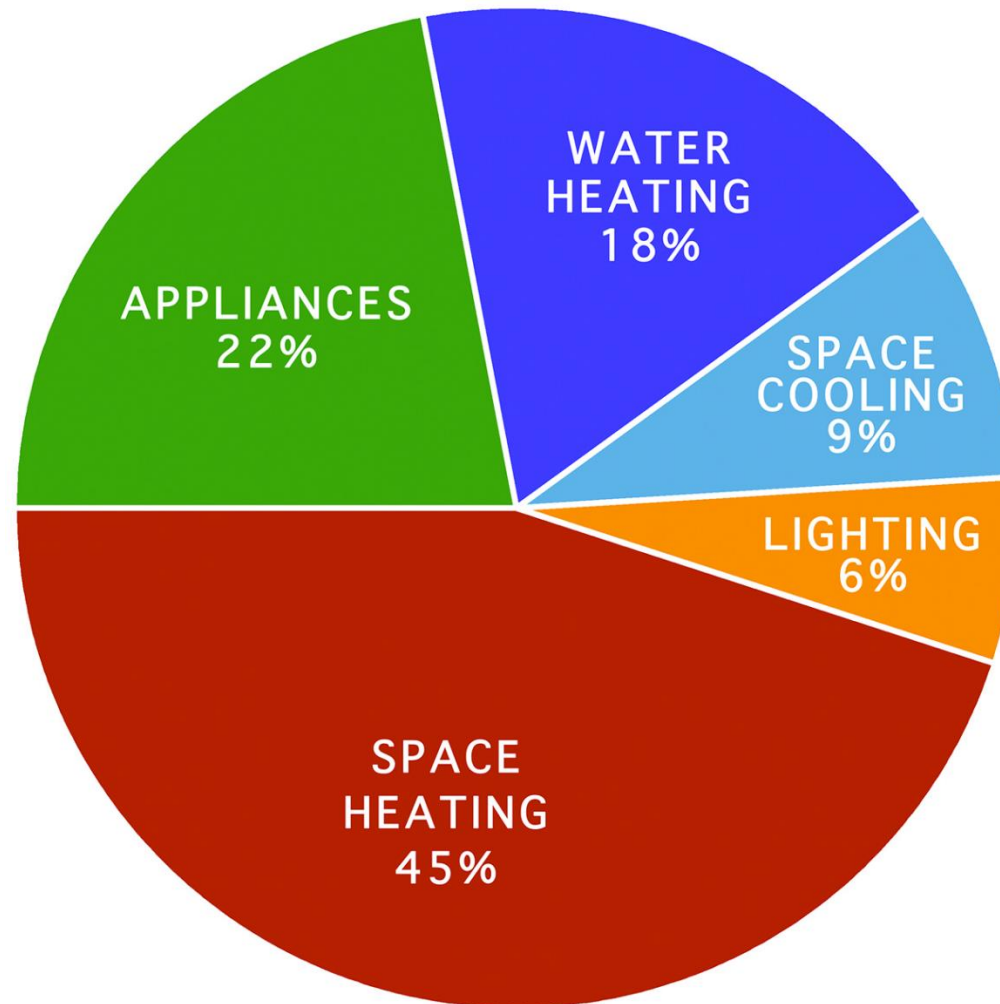
Distribution System

- Most households receive power at 120 and 240 volts
- Business customers may be supplied with single-phase or three-phase power up to 480 volts AC
- Some business customers provide their own distribution transformers, which are supplied directly from the primary distribution feeders
- As close to the customers as possible, the primary distribution voltage is stepped down by distribution transformers to secondary voltages that can be used by the customers.
- Distribution transformers are usually mounted on pole-tops. Utilities also use pad-mounted transformers installed on the ground on concrete slabs or in underground vaults.

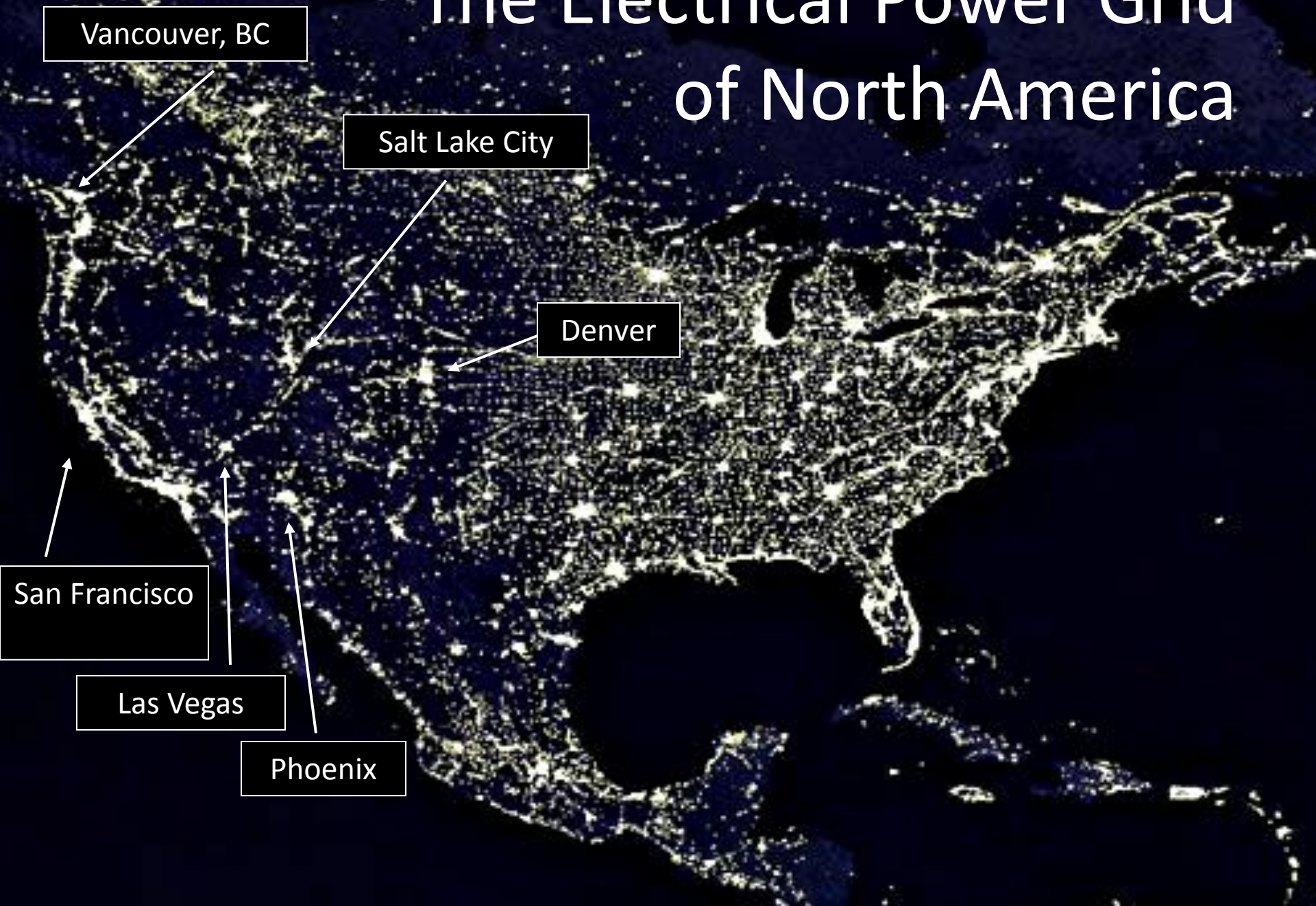


Distribution Transformers

Distribution System Energy Usage In Our Homes



The Electrical Power Grid of North America



How The Grid Works: Burn Radio



Check Your Knowledge:

Power System Overview

1. How is a switching station different from a typical transmission substation?
2. Extra High Voltage (EHV) is defined as
 - a. 230kV to 800kV
 - b. In excess of 800kV
 - c. High Voltage Direct Current
 - d. All Transmission Power Systems
3. Two ways transmission transformers are mounted is, pole mounted and pad mounted (on top of or vault below ground)
 - a. True
 - b. False