Electric Power Distribution

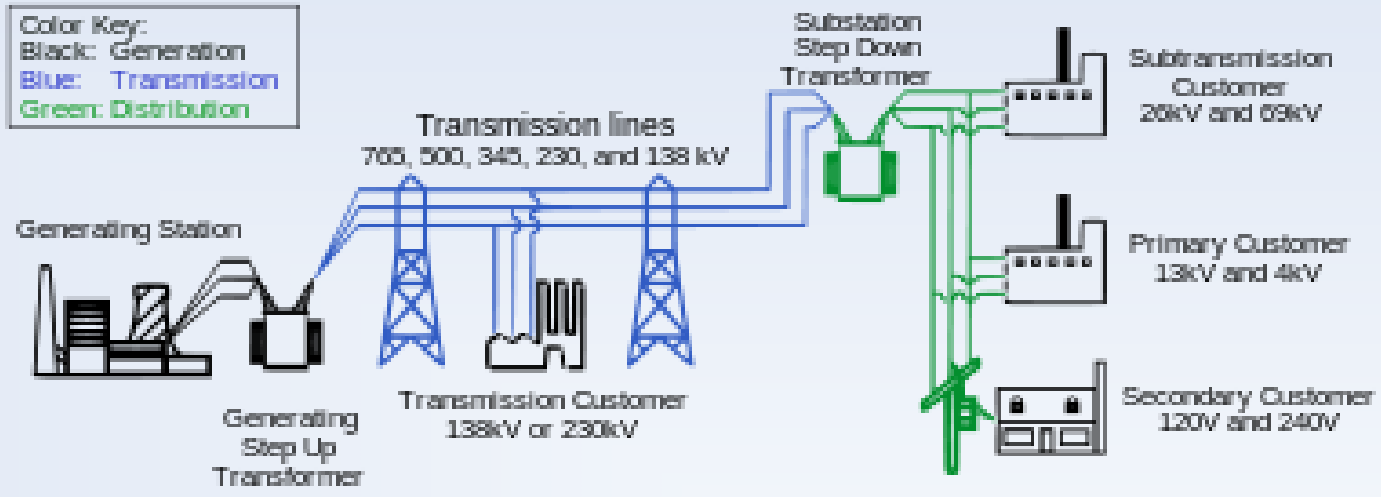
Modules 5A and 5B

Objectives

- Distribution connections
- Distribution system components
- Types of distribution systems
- Distribution system governance and control
- SCADA
- Emerging technologies
- Smart meters and grids
- Scheduled and unplanned outages

How’s it different from transmission systems?

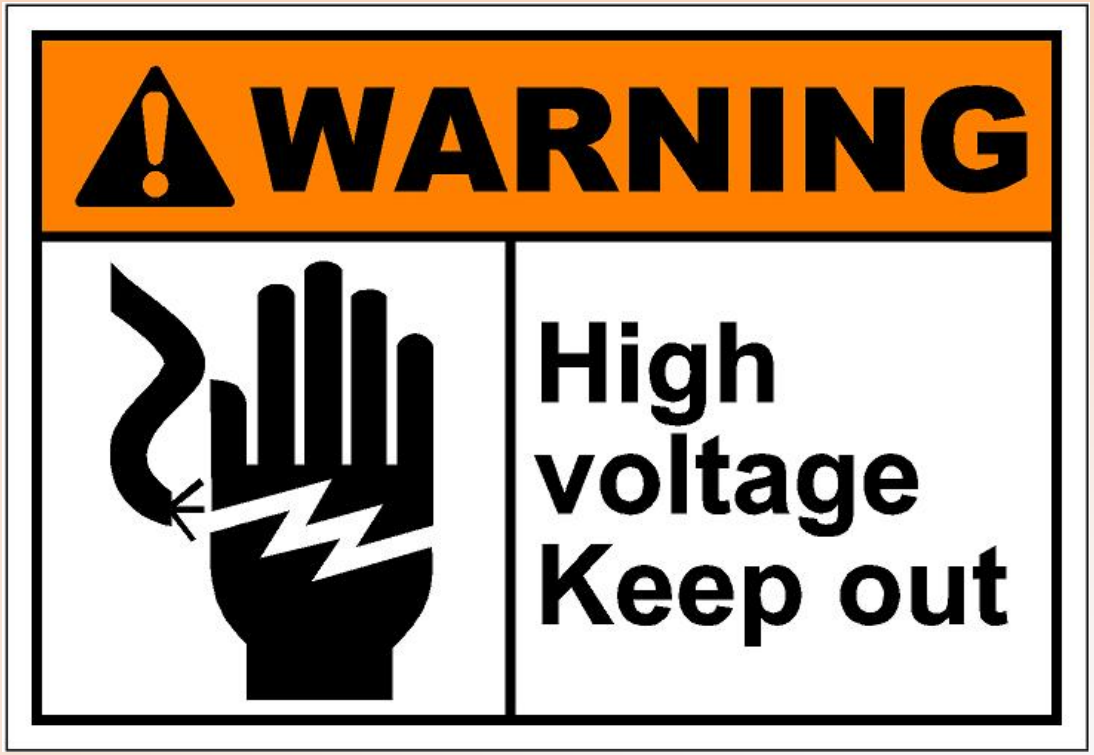
Distributions lines normally run **from substations** through a distribution line network. Distribution networks are **smaller and cover less distance** than transmission systems. Distribution systems operate at **lower voltages** than transmission systems.



How’s it connected?

Substations are interconnected between the transmission system and distribution system by two methods:

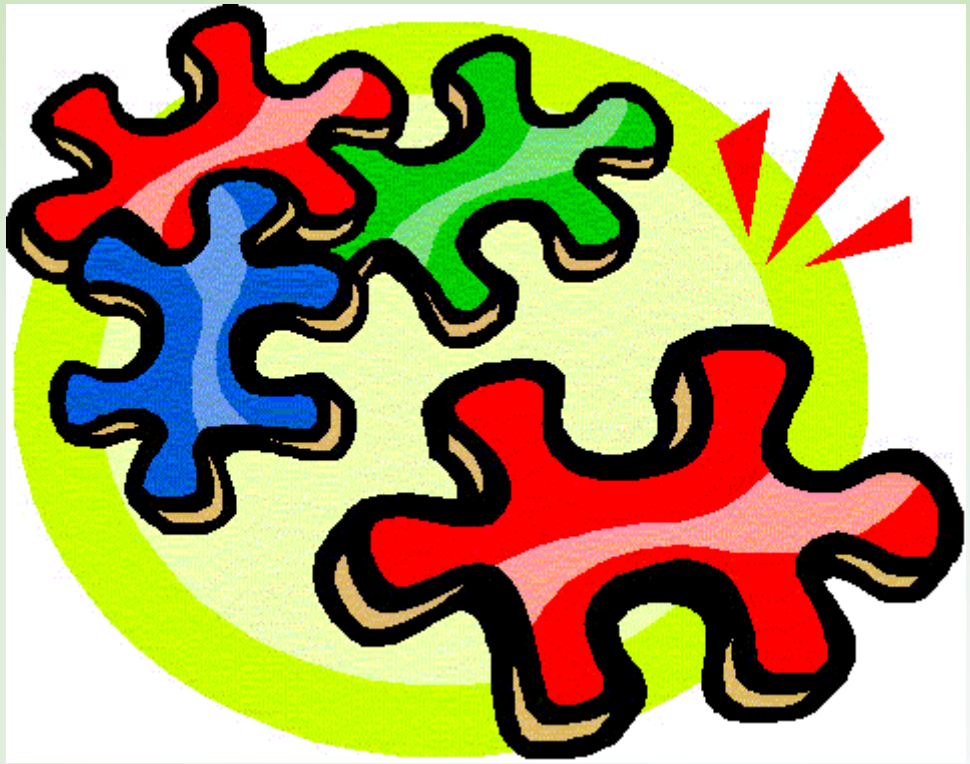
- High voltage **transmission circuits**
- High voltage transmission, circuit-supplying **switching stations**



How’s it connected?

The distribution system is connected within the system by:

- **<u>Distribution</u> substations**
- **Commercial and industrial connections**
- **Residential connections**

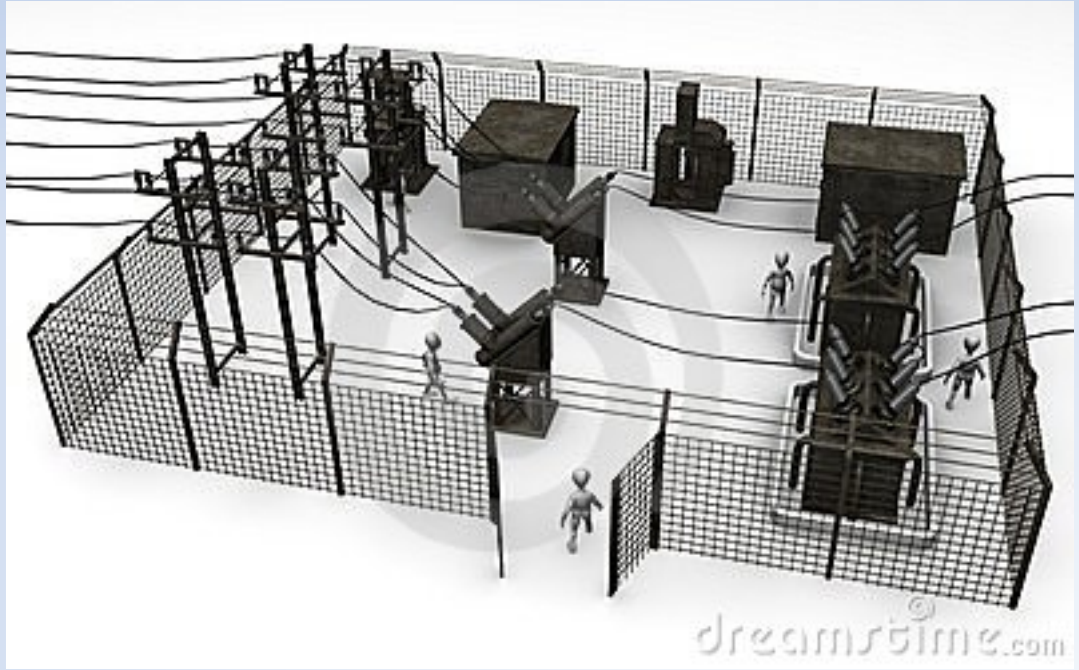


Components of the Distribution System

- Substations
- Distribution feeder circuits
- Switches
- Primary circuits
- Secondary circuits
- Service drops

Components of Distribution <u>Substations</u>

- Transformers
- Distribution **bus**
- Distribution circuits
- Distribution **circuit breakers**
- Distribution **circuit regulators**
- Substation **control house**



Substation Control House

Contains:

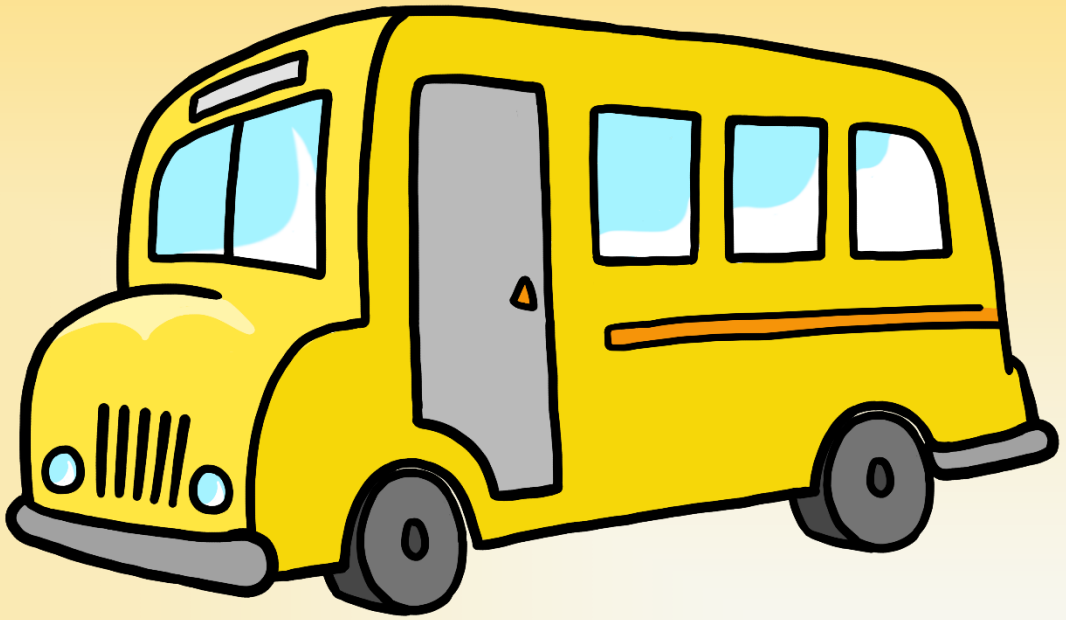
- Switchboard panels
- Batteries
- Battery chargers
- Supervisory control panels
- Meters
- Relays
- Other control system equipment

Distribution Circuits

A substation **distribution bus** allows distribution of power through **multiple sets of distribution lines** at **different voltages**.

Busbars are used as **conductors** to feed power **to two or more** distribution circuits.

Distribution circuits typically consist of distribution **circuit breakers**, **circuit regulators**, and distribution **feeder circuits**.



Distribution Circuits (cont.)

Primary circuits receive their power **from the distribution circuits** and are routed along **local streets** on overhead and underground power lines.

Distribution circuit voltages of 4kV and 13kV are stepped down by **additional transformers** at designated intervals to provide **lower voltages** referred to as **secondary or service voltages**.

High Capacity Customers

High-use customers are serviced by special distribution connections at voltages ranging from **7.2 kV to 14.4 kV** through a service drop, which comes from a transformer.

Service Drops

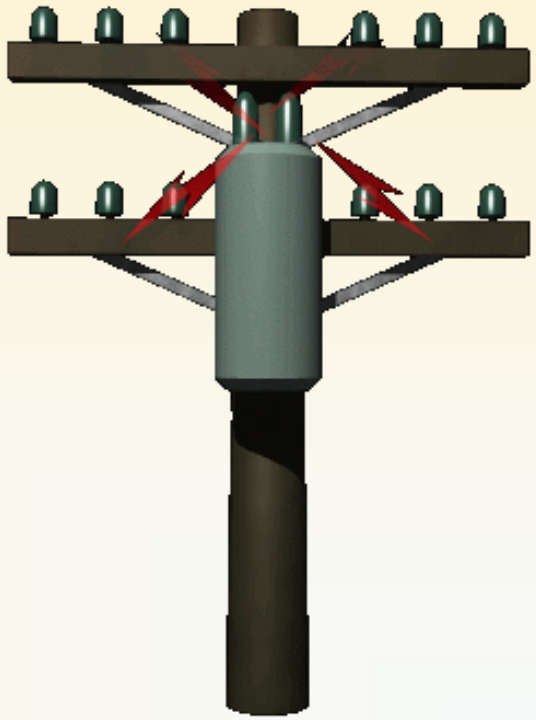
Final connection for the flow of electrical power from distribution system to a customer.

Usually consists of **two 120V lines** and a neutral line, which allows customers to use 120V or 240V.

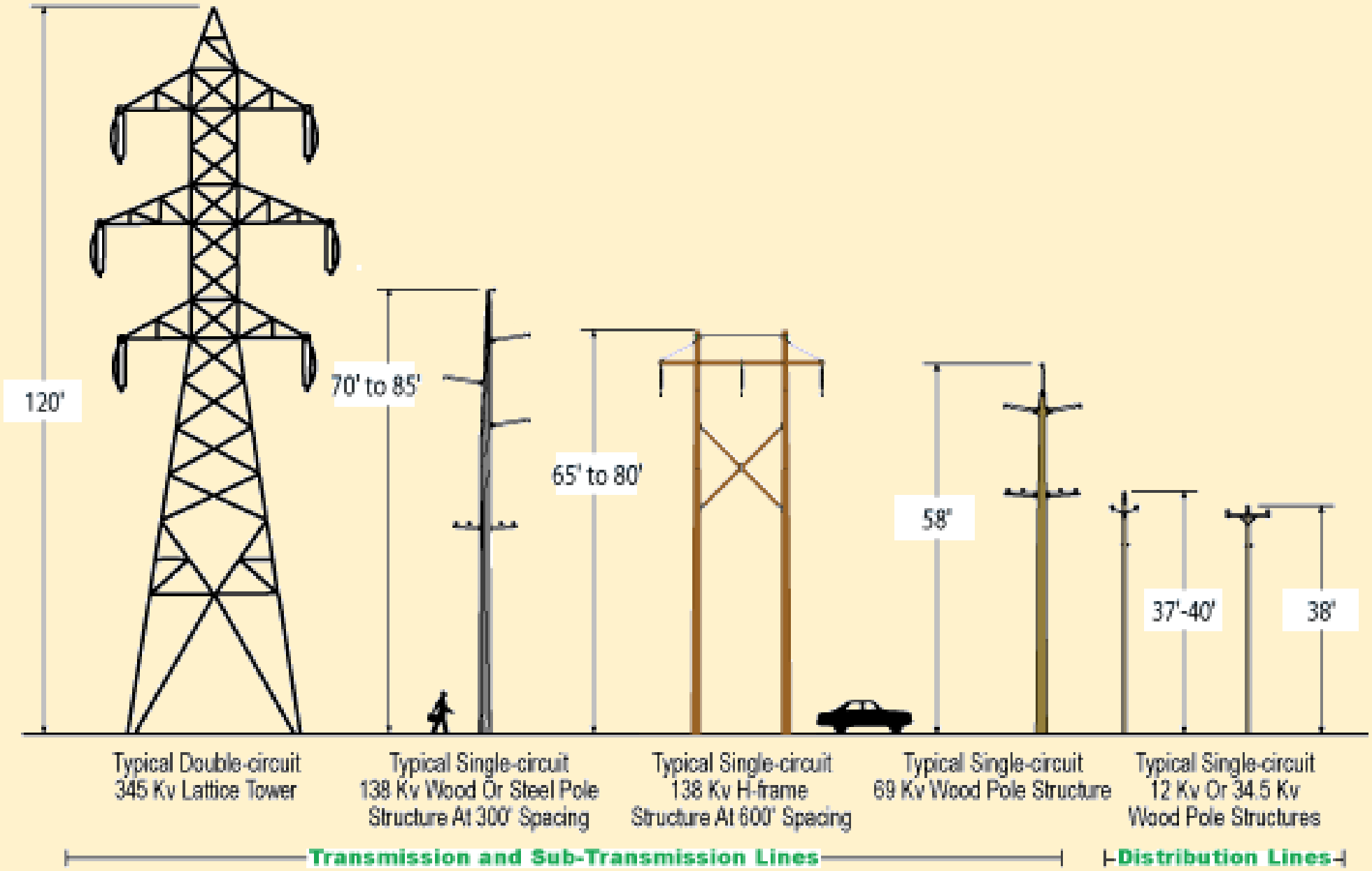
Overhead Distribution Lines

Typically strung between tall wooden poles. As voltage increases, there is also an increase in:

- **Height** of the pole
- **Insulator size**
- **Distance** between conductors
- **Size** of the right of way



Overhead Power Pole and Cable Sizes



Distribution Protection

Right of ways serve as safety mechanisms to maintain clearance between distribution lines and surrounding structures or trees/vegetation.

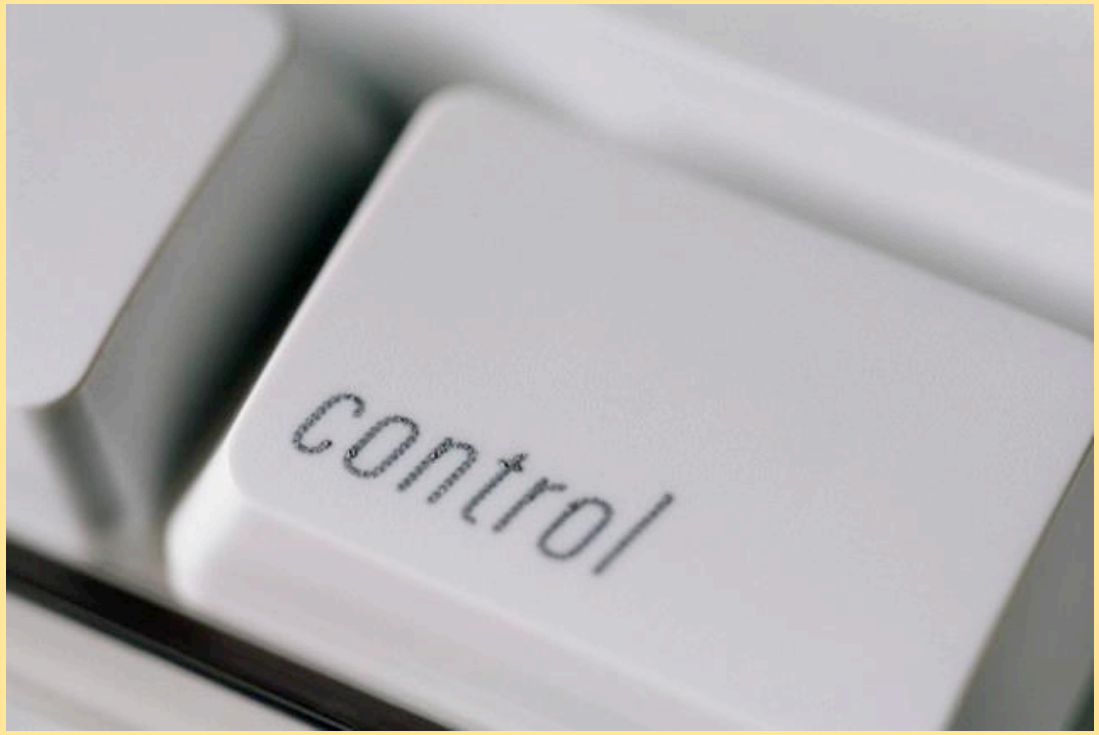
Protective equipment includes:

- Circuit breakers
- Fuses
- Relays
- Switches
- Lightning arrestors

Distribution System Control

Distribution networks are an interconnected part of **centralized control systems** that are constantly **monitored** and **managed** to provide safe and reliable service.

Complex control systems allow operators to supervise and control distribution systems **on-site** or **remotely**.



SCADA

Supervisory Control and Data Acquisition (SCADA) systems collect and use automated data to monitor the movement of electricity from its source at generation plants through transmission and distribution lines.

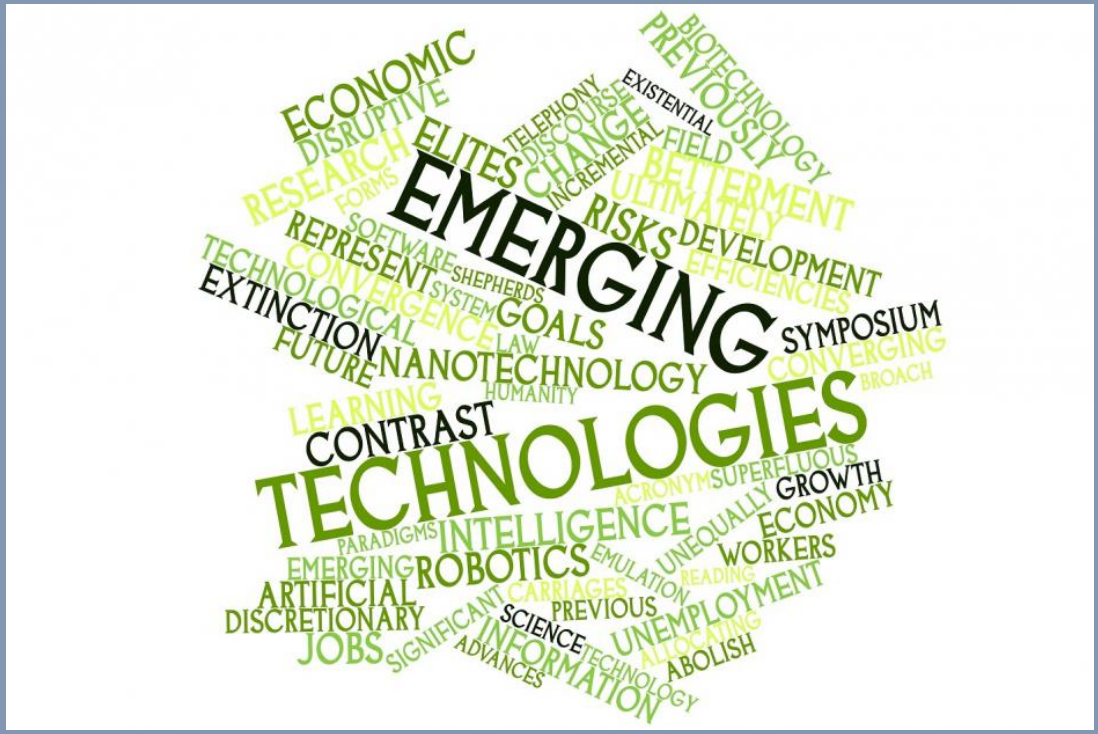
intellect
SCADA SYSTEMS

New Control Systems

New, more advanced supervisory-control equipment and systems allow for more advanced **remote control** of system components. This helps ensure that distribution networks maintain proper and sufficient operations to provide a **safe** and **adequate** electrical power supply.

Emerging Technologies

The main areas of research and development in electric power distribution include new technologies to **increase accuracy and efficiency**. Technologies that enable increased accuracy and efficiency include **automated operations** and **increased monitoring and control capabilities**.



Measuring Electricity Consumption

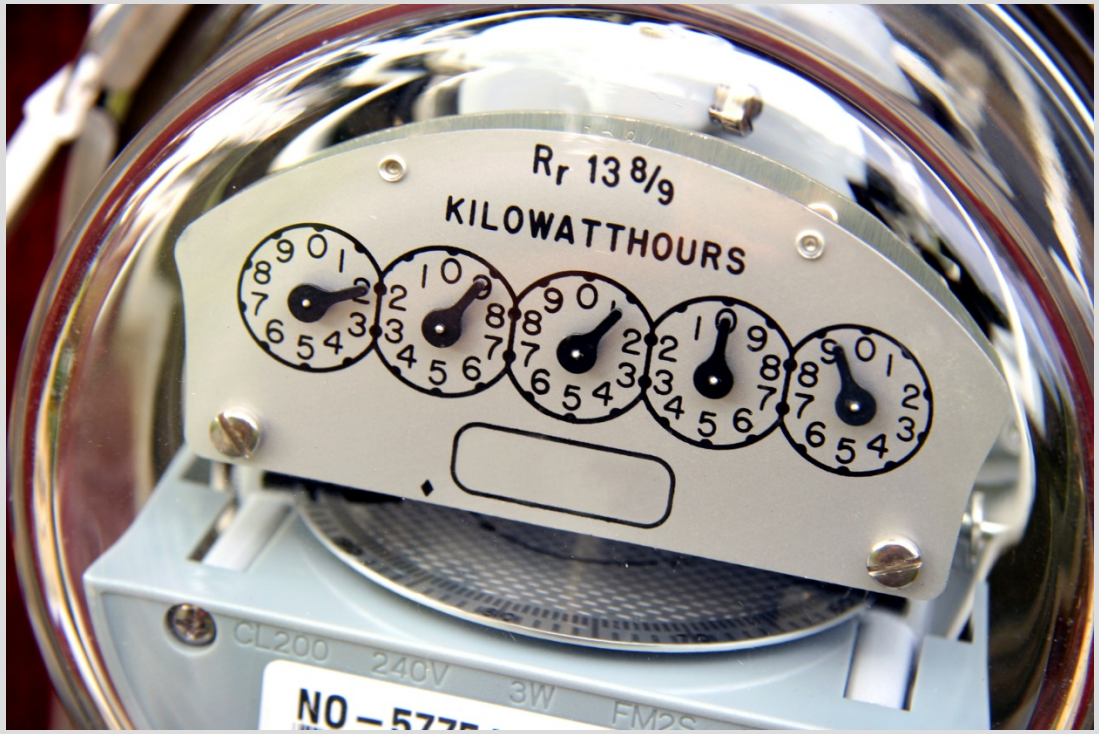
Electric meters are used to measure customers' electricity use. **Automatic meter reading** includes the use of devices that utilize telemetry to remotely collect information from a meter.

Electric Metering Technologies

Electric metering technologies are being updated to provide advanced **bi-directional communication** and monitoring abilities.

Advanced metering technology provides **enhanced sensing** and **measurement accuracy** that allows for the collection and relay of important **real-time data**.

Smart meters will help prevent billing errors and will allow customers to use energy more efficiently.



Going Smart

Coupled with increased accuracy from newer metering technologies, and advanced control systems provide an **improved interface** for real-time, data-driven decision making and demand response.

Smart-grid technologies will provide **more efficient distribution**, **intuitive response to changes** in conditions, and **real-time customer energy-use feedback**.

Radial Distribution Networks

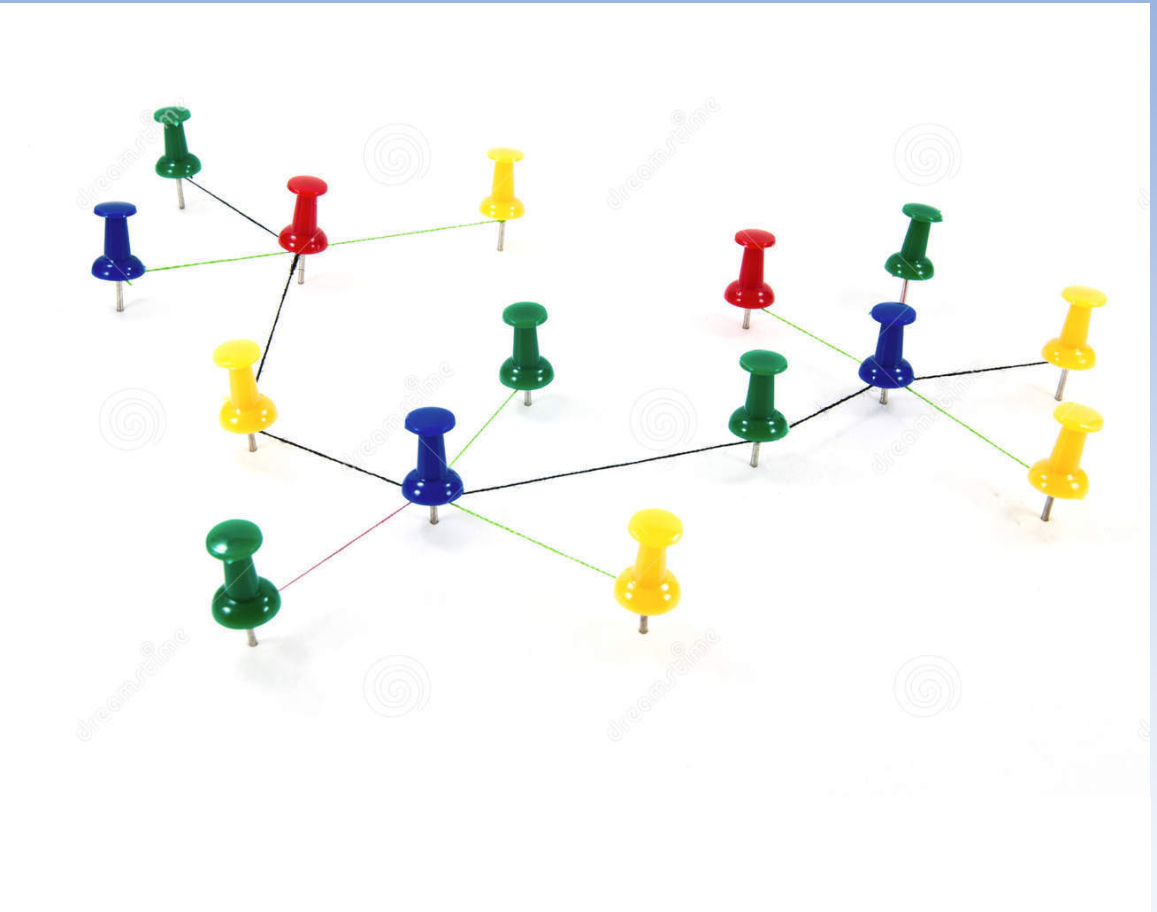
Systems with a single power source for a group of distribution customers.

This is the cheapest type of distribution network, but also the least reliable as there are no redundant power sources.

Interconnected Distribution Networks

Composed of multiple connections to power supply sources and can be configured in a web or a loop.

These systems are more reliable, but also more expensive.



Distribution System Governance

State and local governments are involved in system governance. Similar to the governance of the electric transmission system, distribution systems are **governed by a hierarchy of organizations**.

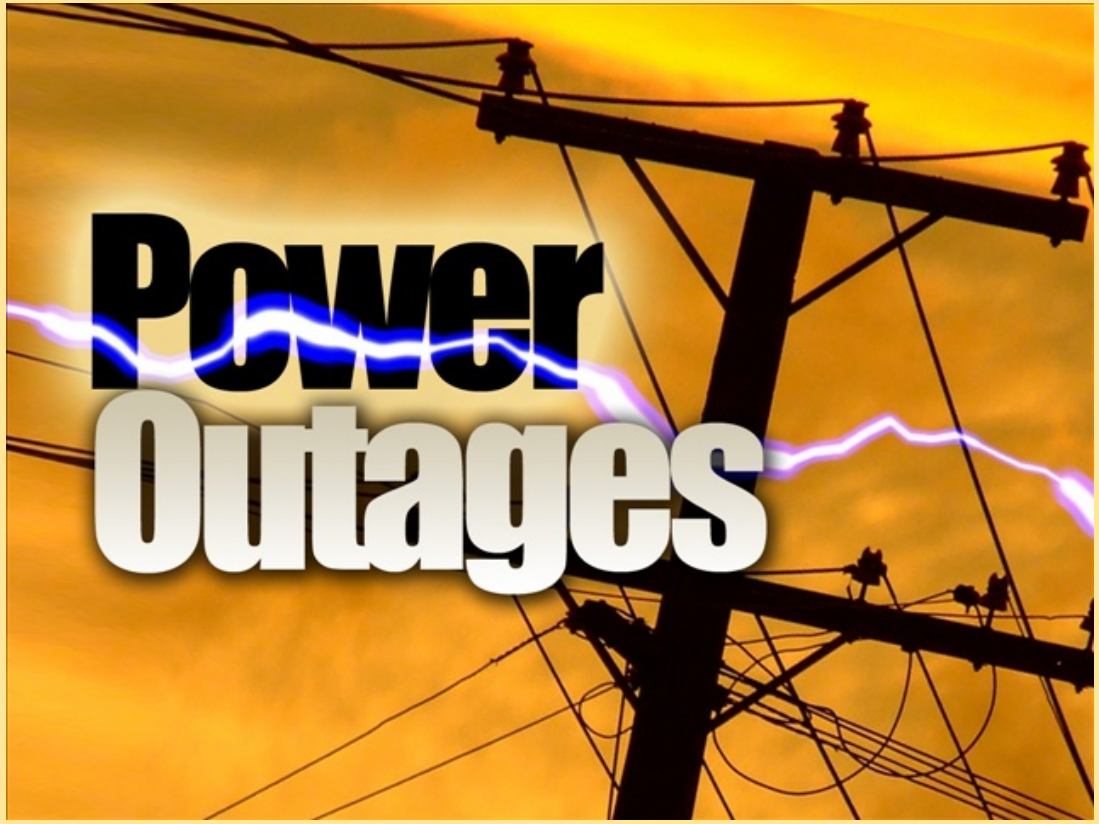
For example, local distribution is controlled by **local** organizations which are controlled by **regional** organizations, which are controlled by **national** organizations.

Outages

Unplanned interruptions in service occur due to:

- Line overload
- Equipment failure
- Severe weather

When a distribution network experiences an outage, it affects a smaller area when compared to transmission system outages.



Scheduled Outages

Scheduled outages happen when a portion of a power system is **intentionally** shut down.

Scheduled distribution line outages are typically pre-planned for activities such as **routine maintenance**, **improvements** or **repair**.

Distribution System Overhead Cables

(Aluminum conductor, steel reinforced)

Review

- Distribution connections
- Distribution system components
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- Distribution system governance and control
- SCADA
- Emerging technologies
- Smart meters and grids
- Scheduled and unplanned outages