STUDENT GUIDE

Energy Industry Fundamentals

CEWD
CENTER FOR ENERGY WORKFORCE DEVELOPMENT

MODULE

5

POWER DISTRIBUTION

STUDENT GUIDE

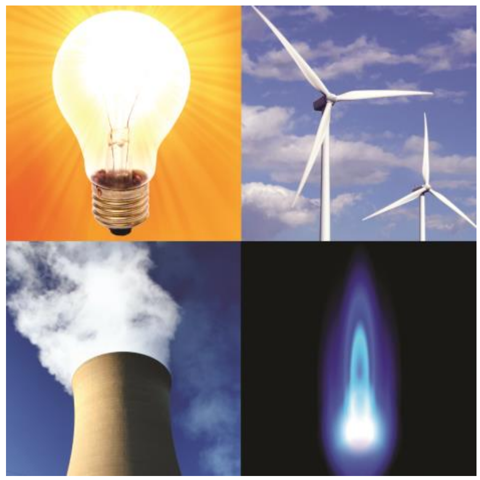
REVISED 06/2018

Center for Occupational Research and Development

Center for Energy Workforce Development

ISBN 978-1-57837-656-4

For questions or additional information regarding these materials, please contact Julie Strzempko at julie@cewd.org.



MODULE

5

ELECTRIC POWER DISTRIBUTION

Table of Contents

Unit A: Introduction to Electric Power Distribution

UNIT A: INTRODUCTION TO ELECTRIC POWER DISTRIBUTION

Distribution System Introduction

As discussed in Module 4, electricity created by generation plants travels though transmission lines, then through distribution lines to reach the end user.

Electric power distribution is the third and final step in the electric power system. Modules 3 and 4 covered electric power generation and transmission. We will cover the distribution of electricity in this module.

While transmission and distribution both refer to the movement and transport of electrical power, it is important to understand the distinction between the two systems.

The electric transmission system typically provides electric power to other intermediate systems. Electrical power distribution refers to supplying electric power to retail or end-use customers. Distribution lines normally run from **substations** through a distribution-line network to individual customers. Geographically speaking, distribution networks are smaller and cover less distance than transmission systems.

Another distinction between distribution and transmission systems is the operating **voltage**. Transmission systems operate at higher voltage levels than distribution systems.

Historically, early **electric power distribution systems** encountered obstacles similar to those experienced by early transmission systems: mandatory proximity to a generation source and incompatibility of different voltages. Today's extensive distribution systems were not possible as there was no efficient means of changing voltages, and technology regarding the safe distribution of residential power was primitive.

Focus on ...

Transmission vs. Distribution

Transmission

- Higher operating voltages
- Longer distances
- Larger coverage area
- Provides power to other systems

Distribution

- Lower operating voltages
- Shorter distances
- Smaller coverage area
- Provides power to individual customers

Distribution System Overview

Distribution Substations

As explained in Module 4, the voltages that are required for bulk electricity transmission are too high for most consumer applications. Lower voltage levels are required for electricity to flow safely through smaller cables and distribution lines. At transmission interconnection intervals such as substations, some of the electrical energy is tapped off the transmission lines. These substations step the voltage down to lower voltage levels with large power **transformers**.

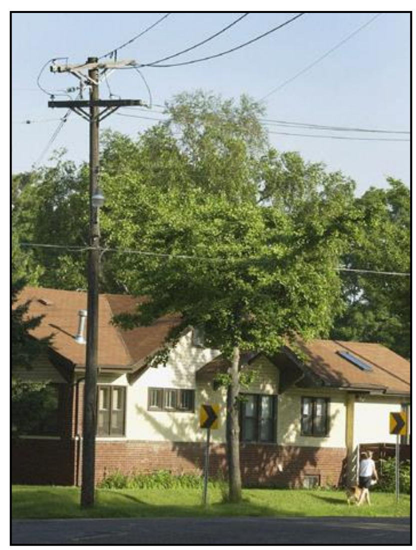
Substations are interconnected and dispersed among high-voltage transmission lines and distribution lines. They vary in size depending on the system they are servicing. Most substations are constructed in an area where the vegetation has been removed, and the lot is filled with gravel and is fenced and gated for safety and security.

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

- High-voltage transmission circuits carrying 138 kV or 230 kV directly **step-down** voltage to distribution connections carrying 13 kV.
- High-voltage transmission, circuit-supplying **switching stations** step-down voltages to a **subtransmission** voltage level commonly in the range of 26 to 34 kV. The subtransmission circuit's voltage level can easily be routed along public streets on wood poles or through underground cables to industrial, commercial, and utility substations. These subtransmission-supplied substations provide system monitoring and control for distribution circuits in the 4 and 13 kV range.

Commercial and Industrial Connections

Some customers need higher voltage levels than what is typically provided from a residential distribution circuit but do not need voltages that are high enough to warrant a direct connection to the transmission system. These high-use customers are serviced by special distribution connections at voltages ranging from 7.2 kV to 14.4 kV through a **service drop** line that comes from a transformer on or near a distribution pole to the customer's end-use structure.



© 2011 Minnesota House of Representatives, Public Information Services

Residential Connections

Residential customers require electricity that is distributed at a reduced voltage, typically 120/240 **volts** (single phase). This reduced voltage is usually achieved through a pole-mounted or pad-mounted transformer.

Electrical power is delivered to residential customers through what is referred to as a service drop line, which leads from the distribution pole transformer to the customer's structure via overhead distribution lines. The service line can also be buried, as is the case with underground distribution lines. Residential connections and key components will be discussed in more detail later in this unit.

Focus on ...

Electric Power Distribution Pathway

- Substation steps down voltage from transmission lines
- Primary distribution lines route power to a specific service area
- Secondary distribution lines route power to smaller areas within a service area
- Transformers step down the voltage to the appropriate level to be routed directly to a building's service line and through an electric meter

☼ ACTIVITY: Types of Distribution Networks

Collect information on the varying types of distribution networks by using your local library, Internet, and local utility personnel. Research the advantages and disadvantages of the different types of networks, and find out what type of distribution network serves your local area.

Answer the following questions:

"Are there any specific factors in your area that influenced the development of one type of network design over another, such as geography, proximity to transmission lines, or generation sources?"

"Do local utilities have contingency plans in place based on the type of system they are operating in the event of a system problem or outage?"

Distribution Networks

Distribution networks are usually either radial or interconnected. **Radial distribution networks** are systems with a single power source for a group of distribution customers. In radial systems, distribution lines stem from a single power source and continue through the service area without a connection to additional power supplies. This is the cheapest type of distribution network, but also the least reliable as there are no redundant or back-up power sources. This type of system is more common in remote locations or in locations with a low population density.

Interconnected distribution networks are composed of multiple connections to power supply sources. Interconnected systems are configured in a "loop" with power sources located in various locations along the loop, or in a "web" with power sources interconnected within a complex framework. Interconnected systems are more expensive than radial systems, but they offer a much higher level of reliability due to the redundancy of power sources.

Focus on ...

Important Factors for Electric Power Distribution Systems

- System power demand requirements
- Distance the system must cover
- Projected operation and maintenance required and associated costs
- Physical clearances and requirements for system components
- Potential environmental and community impacts
- Integration into the national grid

Siemens, 2016

Distribution Systems and Equipment

Designing distribution systems requires significant planning and forethought. Numerous systems and essential equipment comprise a distribution system.

Focus on ...

Electric Power Distribution System Components

- Substations
- Distribution Feeder Circuits
- Switches
- Primary Circuits
- Secondary Circuits ("Secondaries")
- Services ("Service Drops")

OSHA, 2011

Most of us are familiar with the sight of electrical transformers on poles in residential neighborhoods or **electric meters** attached to our homes. These transformers and meters are examples of important components of the electrical distribution systems that serve our communities.

Distribution Substation

We have mentioned that we need higher voltages to move large amounts of electricity long distances with minimum losses (voltage drops). However, we also need lower voltages to allow smaller power lines and associated equipment to be built for residential purposes. This also allows customer equipment and appliances to operate at standardized voltages.

A key element in the distribution system is the distribution substation. Substations are fenced-in areas that contain switches, transformers, and other specialized electrical equipment that convert electric power from the transmission system to a distribution voltage level. Distribution substations are where distribution circuits originate, are monitored, and are adjusted. See Figure 5A.1.

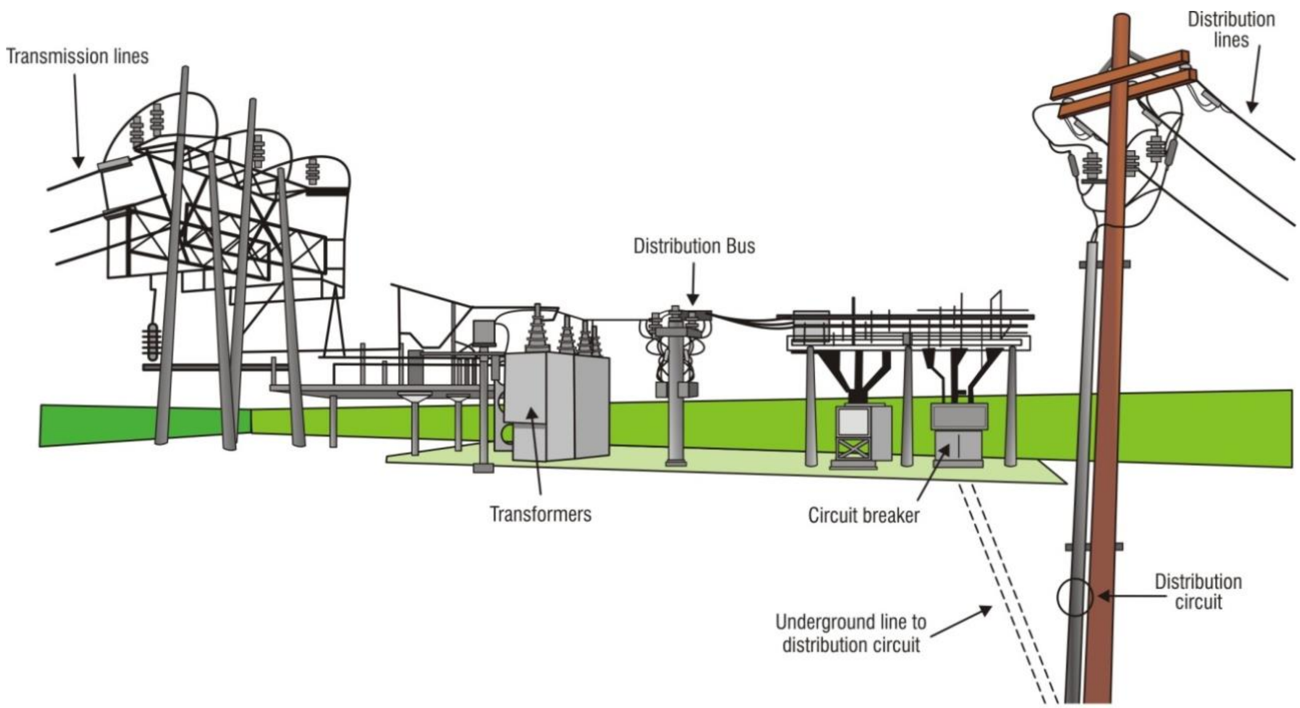


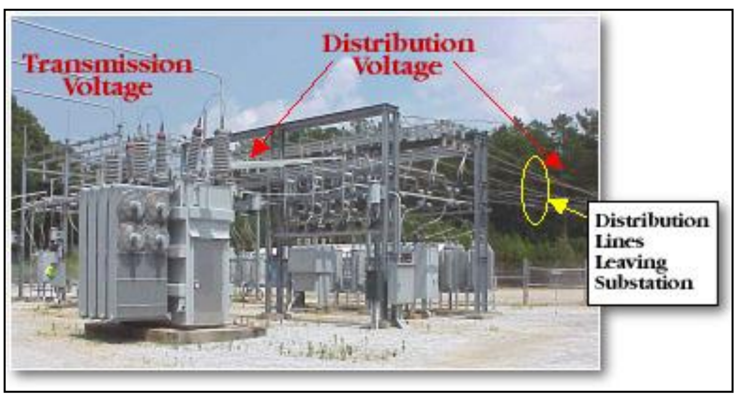
Figure 5A.1 Distribution Substation

☼ ACTIVITY: Substation Copper Theft

Copper wire theft is becoming a serious problem for utility companies. Copper wire is frequently used in the construction of transformers as well as for ground wires of utility poles. Not only is copper theft illegal, it is also very dangerous and can even be deadly as it has caused explosions, fires, electric outages, and death. Copper theft is not only damaging to electric power equipment, but it is detrimental to all consumers as it results in electric power outages and increased rates to cover the costs of damages.

In teams, research and report to the rest of the class what types of technology or specialized procedures are being used by utility companies to prevent copper theft.

What additional types of procedures or special technologies can you think of that might be useful for stopping copper theft?



Focus on …

Distribution Substation Functions

- Change voltage from one level to another
- Regulate voltage to compensate for system voltage changes
- Switch transmission and distribution circuits into and out of the grid system
- Measure electric power qualities flowing in the circuits
- Connect communication signals to the circuits
- Eliminate lightning and other electrical surges from the system
- Make interconnections between the electric systems of more than one utility

OSHA 2017

Distribution Substation–Key Components

Transformers

Substations contain transformers that step-down voltages from transmission voltage levels, which range from 44,000 volts (44 kV) to 500,000 volts (500 kV) to distribution voltage levels, which range from 4,000 volts (4 kV) to 35,000 volts (35 kV).

As discussed in earlier modules, a transformer is an electrical device that changes **alternating current** (AC) of one voltage value to another voltage value. A basic transformer consists of two windings coiled around an iron core. The primary winding is connected to the source voltage. The secondary winding is connected to the **load**.

To achieve the appropriate distribution voltages, substations utilize **step-down transformers**. A step-down transformer has more turns in the primary winding than in the secondary winding. Voltages are higher in the **primary circuit** than in the secondary circuit. A substation typically consists of one or more power-transformer banks that contain multiple transformers.

Distribution Bus

Once electrical power leaves the transformers, it is routed to a **distribution bus**, a steel structure array of switches that is the first step in the process of routing power out of a substation. A substation bus allows distribution of power through multiple sets of lines at different voltage levels.

Within the distribution bus array, rigid tubular or rectangular bars, called busbars, are used as **conductors** to feed power to two or more distribution circuits.

Distribution Circuits

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

Distribution circuits supply the majority of electrical power customers rather than the transmission or **subtransmission systems**. Primary circuits (“primaries”) receive their power from the distribution circuits. Primary circuits are routed along local streets on overhead and underground distribution circuits. Typically, additional transformers step down distribution circuit voltages of 4 kV and 13 kV at designated intervals to provide lower voltages for specific customer applications. These lowered, customer-application voltages are referred to as secondary and services voltages.

Distribution Feeder Circuits

A distribution feeder circuit routes power from the substation to primary circuits. Distribution feeder circuits are the connections between the electrical power output of the distribution substation and the input terminals of distribution primary circuits. Power from distribution feeder circuits leaves the substation through a distribution circuit breaker. The power exits the circuit breaker, typically through underground cables, and routed to an overhead primary circuit outside of the substation. Multiple distribution feeder circuits can exit a substation extending in different directions.

Distribution Circuit Breakers

Just like circuit breakers in your home, distribution circuit breakers protect the wires or lines in a distribution circuit. Circuit breakers automatically disconnect power to a circuit if there is a failure, abnormality, or interruption in an electric line. Circuit breakers and switches can also be used to disconnect the distribution substation from the power grid.

Distribution Circuit Regulators

Distribution circuit regulators are used to continuously adjust the voltage level in a distribution circuit so customers receive constant service voltage which is required for proper operation of household appliances.

Substation Control House

Some substations have a **control house** located within the substation yard. A substation control house contains switchboard panels, batteries, battery chargers, supervisory control panels, meters, relays, and other control systems equipment. The control house provides weather protection and security for the equipment it houses.

Operators who are actually present at the substation site may control substations, or they may be controlled by an automated system or by remote operators at another site. Most newly constructed substations are either automated or remotely controlled.

Primary Circuits

Electric power begins its final trip to consumers through primary circuits leaving the distribution substation. Primary circuits are the distribution circuits that carry power from substations to local distribution service areas. Primary circuits may also be referred to as primaries or distribution main feeders.

☼ Career Profile: Substation Technician

Don D. is a substation technician for a local power company. As a substation technician, Don operates equipment and systems, and performs preventative and corrective maintenance on it at a local distribution substation. Don graduated from high school and attended a local community college, where he received an associate's degree in substation technology. On a daily basis, Don is responsible for inspecting, testing, maintaining, repairing, and installing various equipment and systems at his assigned substation.

Don maintains accurate logs of the data he collects and looks for any abnormalities that might indicate problems that need to be addressed. He is also skilled in many different computer applications that are needed to monitor and control computer-based and automated substation systems. Don utilizes appropriate safety practices and procedures while on the job to ensure his safety and the safe delivery of electric power to customers.

Distribution Lines

There are many different designs of distribution lines that can usually be categorized within two main types: overhead distribution lines and underground distribution lines.

Overhead Distribution Lines

Similar to transmission lines, the majority of distribution lines in the United States are overhead distribution lines. Overhead distribution lines consist of heavy cable strung between tall electric poles.

Design Specifications

As with transmission systems discussed in Module 4, the design of the equipment used in electric power line systems is usually based on the voltage load that the system will be carrying. See Figure 5A.2.

As line voltage increases, typically there is also an increase in the following: the height of the pole or cable-supporting structure, **insulator** size, distance between conductors (lines) on the tower/pole, and the size of **right of ways** (ROWs).

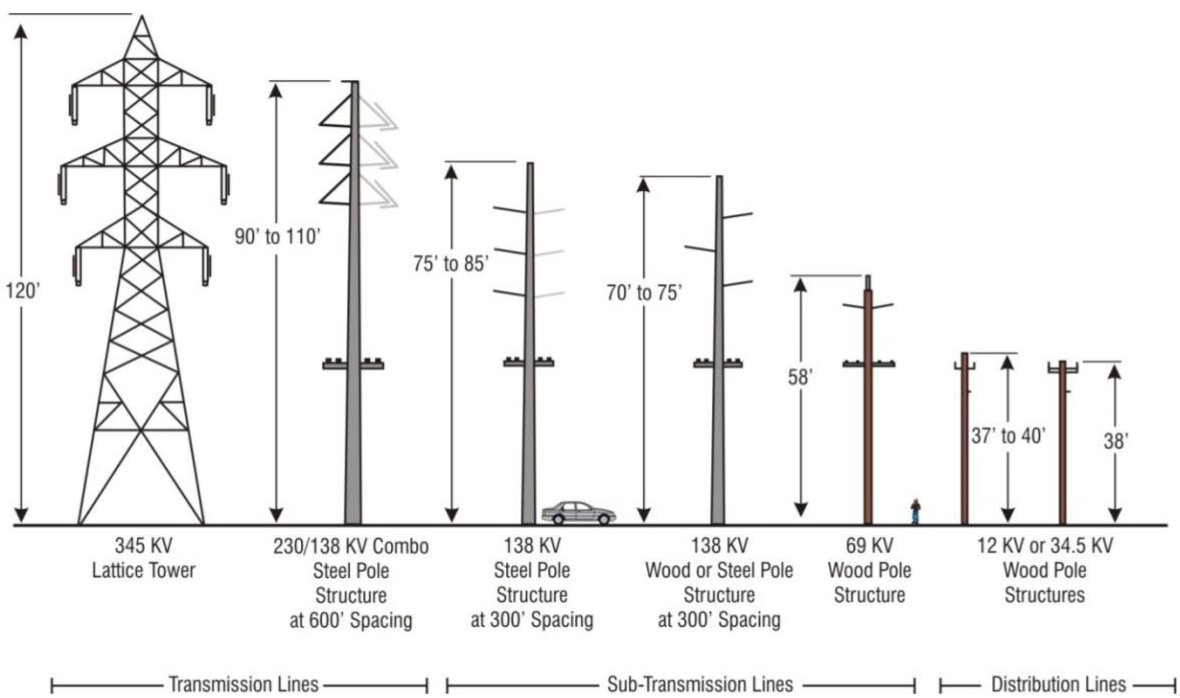


Figure 5A.2 Designs ©2011 Image adapted from Idaho Power

Poles

Overhead distribution lines are typically strung between tall wooden poles. The basic function of an electric pole is to isolate the lines by elevating them.

The elevation and clearance of electrical power lines is a safety precaution. High-voltage transmission lines are very tall, while some lower voltage lines, such as most distribution lines, are carried by wooden towers that are not as tall. In the distribution system, the poles are generally shorter and often made of wood. Distribution lines in cities may be supported by breakaway metal poles to reduce injuries in case a vehicle runs into them. All power line towers and poles are designed to keep the lines from contacting any objects in the surrounding environment and to keep the lines from touching each other.

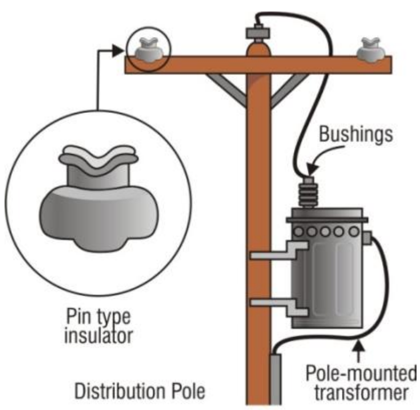
Conductors

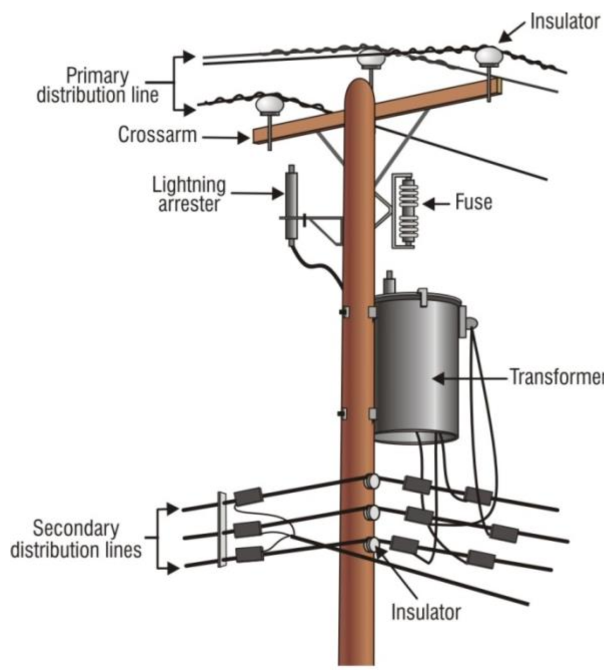
Just like overhead transmission lines, overhead distribution lines consist of the "power line" which is also called the cable or conductor. Electricity travels through the path of least **resistance** so lines are made from materials that electricity can travel through easily.

©2011 Composite Technology Corp.

Overhead lines are usually composed of several strands of an aluminum alloy coupled with steel strands that serve as reinforcement material for added strength. The majority of overhead distribution lines are un-insulated because they are elevated on poles or towers.

"Feeders" are conductors that are leaving a distribution substation. "Primaries" are distribution lines that are directly connected to the distribution substation which are at a higher distribution voltage. These primary lines branch farther out through distribution transformers that lower the voltage to travel down a secondary line, or "secondaries." A service drop runs from the secondary line to the customer's meter.





Insulators

Insulators support the conductors and are used at conductor connection points. Insulators are designed to prevent line contact that would result in a fault and to limit conductor sway. Insulators may support the conductor above the pole attachment or they may be a part of suspension-type design in which the conductor hangs below the pole attachment. Insulators are usually made out of specialized ceramics such as porcelain, glass, or glass-reinforced polymers. Their design is based on line voltage.

Right of Way

Just like transmission towers and lines, a right of way (ROW) also protects distribution poles and lines. The right of way for a distribution system might be smaller than that of a transmission system, but it is still defined as the land set aside solely for the use of distribution towers, lines, and associated facilities. Right of ways serve as a safety mechanism to maintain clearance areas between distribution lines and surrounding structures or trees and other vegetation.

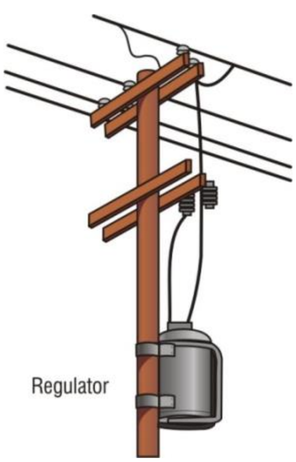
Underground Distribution Lines

Underground distribution lines are buried or placed in tunnels or trenches. Placing the lines underground offers reduced visual impacts and more protection from damage by weather, wind, and trees. Underground lines are an expensive alternative to overhead distribution lines.

In some neighborhoods, you can see large green transformer boxes in yards. These are underground distribution transformers and their presence is an indicator of the existence of underground distribution lines.

Protective Equipment

Distribution systems employ several different types of protective equipment and systems. Examples of protective equipment utilized include: circuit breakers, fuses, relays, switches, and lightning arrestors. These safety systems allow power flow to be redirected or stopped to prevent damage to distribution lines and equipment in the event of a short circuit, lightning strike, or other damaging incident.



Regulators

<u>Regulators</u> are another important part of distribution systems. Regulators are located strategically along distribution lines. A regulator is responsible for regulating voltage on a distribution line. They may be found attached to distribution poles, or they may be constructed on elevated platforms on power poles in groups in an arrangement referred to as a “regulator bank.” Regulators can also be constructed underground.

Capacitors

Another example of a voltage-regulating device used in distribution systems is a **capacitor**. A capacitor is a device that can store electricity and briefly release it to assist in voltage regulation and correction. Capacitors are located in distribution substations in addition to being pole-mounted on distribution lines.

Distribution Transformers


©2011 CDC

While a distribution substation lowers the voltage of electric power from the transmission system, the voltage needs to be lowered again before it is routed to its final destination at a customer's home or place of business. Along distribution lines, there are special distribution transformers that lower voltages to the levels needed by the customer. In a residential setting, a pole-mounted transformer may supply as many as eight houses.

Distribution transformers may be pole-mounted or pad-mounted on concrete "pads" on the ground.

☼ ACTIVITY: Use of Transformers in the Electric Power System

Transformers come in a wide array of designs and materials, but their essential functions remain the same. Transformers are a fundamental part of electric power generation, transmission, and distribution systems. Review the information presented in this course that you have covered regarding the use of transformers in the electric power industry.

©2011 OSHA

Create a chart which compares and contrasts the essential functions that transformers perform at different stages of electric power generation, transmission, and distribution processes.

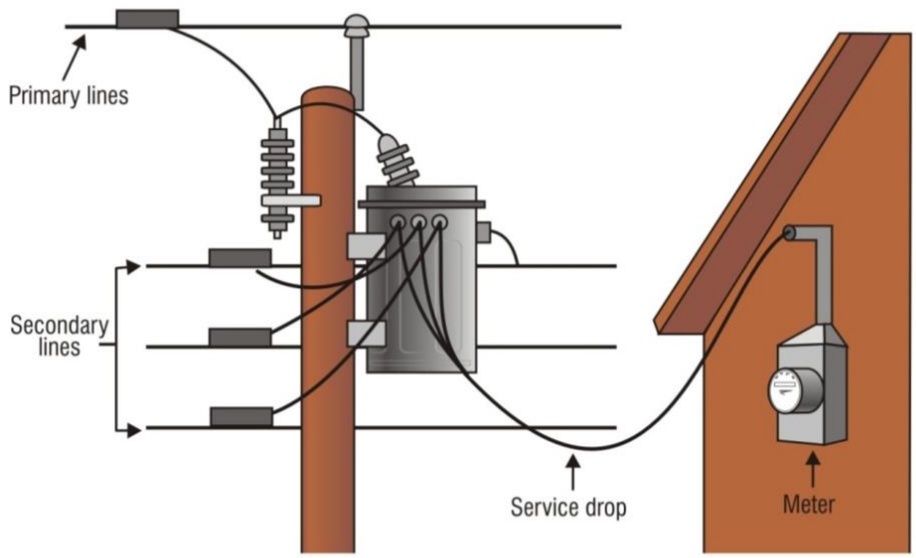
Ground Wire

Power-line poles are installed with wires called **ground wires** that span the length of the pole and extend down into the ground about eight feet.

A ground wire provides a safe path for leaked or unintended (lightning) **current** to travel away from the distribution system and down into the ground to prevent damage, fire, or shock.

Electrical Service Drop

The wires that run from the secondary distribution lines or distribution transformers to a customer's house or place of business are collectively called the "service drop." The electrical service drop is the final connection for the flow of electrical power from the distribution system to a customer's electric meter. A service drop can originate from an overhead or underground connection. See Figure 5A.3.



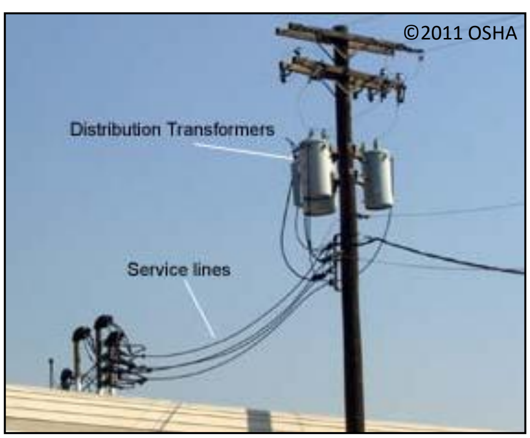


Figure 5A.3 Electrical Service Drop

Most of the electrical distribution service drops in the United States are a single phase 120/240-volt service. The service drop usually consists of two 120-volt lines and a neutral line which allows customers to get 120 or 240 volts of power.

> Focus on …
>
> **Common Customer Voltages**
>
> **Residential (Single-Phase Services)**
> - 120 volts
> - 120/240 volts
> - 120/208 volts
>
> **Commercial and Light Industrial (Three-Phase Services)**
> - 120/208 volts – 3-phase **wye**
> - 277/480 volts – 3-phase wye
> - 120/240 volts – 3-phase **delta**
> - 240 volts – 3-phase delta
> - 480 volts – 3-phase delta

Electric Meter

Electric meters are needed to measure and account for the amount of electrical power used by customers. Electricity is used and paid for by customers in a unit known as a **kilowatt-hour** (kWh). A kilowatt-hour is equal to 1,000 watts of electrical energy used in one hour. An electric meter is made of an electric motor that is connected to a set of dials that are calibrated to turn at a specific rate when a customer uses electricity. When electricity flows through an electric meter, it powers the motor and the motor turns the dials.

©2011 U.S. DOE

Electric metering technology has been a recent focus of many utility companies. Newer electric meters are being constructed with updated features and capabilities. In addition to new digital displays instead of the older analog dial displays, many meters are being equipped with advanced remote reading and communication capabilities. **Automatic meter reading** (AMR) includes the use of devices that utilize **telemetry** to remotely collect information from a meter. AMR can enable diagnostic data as well as consumption data to be collected automatically from meters.

☼ Career Profile: Electric Meter Technician

Mike G. has been an electric meter technician for ten years. Mike says, “There have been a lot of changes in the electric metering field since I started working in it.” Mike says what once was a relatively low-technology field has evolved into a high-technology field. “With the increased pressures on utility companies to update system components to meet smart grid capabilities, electric metering has gone high-tech. Lately, I spend most of my time replacing old analog meters with newer, digital smart meters.”

In addition to installing new meters, Mike is responsible for the troubleshooting, repair, and maintenance of a variety of equipment used in electric metering systems. When Mike graduated from high school, a local utility company hired him, and then he trained in an apprenticeship program to become qualified as a meter technician. Since his original coursework, he has been required to attend several continuing education courses to keep up with the changing metering technologies. Mike says, “A typical day used to be walking around all day reading dial meters and writing the information down in a log book. Now we can automatically collect information from a meter with handheld devices that communicate directly with the meter.”

©2011 Ildar Sagdejev

Mike adds, “You have heard the saying, ‘work smarter, not harder;’ that is what the latest advances in electric metering are allowing us to do. As long as I do my job and properly install and maintain the metering equipment, the system does all the hard work of accurate data collection and reporting.”

☼ ACTIVITY: Electric Meters

Invite a local meter technician or meter reader to speak to the class. Ask the technician to explain how older analog and newer digital and “smart” meters operate. Have the technician show the class how to read both analog and digital meters. Be sure to ask questions about the advantages and disadvantages of the installation, use, and repair of analog meters versus newer digital meters.

After the technician’s presentation, keep a log of your meter’s readings until your next electric bill arrives. Does the final reading on your billing statement match up to your recorded data?

Unit A Glossary

alternating current (AC)—an electric current that reverses its direction at regularly recurring intervals

automatic meter reading (AMR)—the use of devices with remote reading capabilities to collect information from an electric meter

capacitor—a piece of equipment used in electric power distribution systems that assists in regulating and controlling voltage through electric power storage and release capabilities

conductor—material such as copper or aluminum that allows electrical current to flow freely through it; in electric power transmission and distribution, conductor also refers to the actual "power line" or cable

control house—a structure that is built within the substation yard that houses electric power distribution monitoring and control equipment

current—a flow of electrons in an electrical conductor; the strength or rate of movement of the electricity is measured in amperes (amps)

delta—a method of wiring for a three-phase connection in which three windings of a transformer or generator are connected end to end; when drawn in a line diagram, the shape resembles the Greek letter delta (Δ)

distribution bus—a structure commonly found at a distribution substation that is composed of switches that route power out of the substation

distribution circuit breakers—pieces of equipment designed to protect components in an electric distribution circuit in the event of a system failure or problem

distribution circuit regulators—pieces of equipment that adjust voltage levels in distribution circuits to maintain a constant voltage level in the system

distribution feeder circuits—the connections between the electrical power output of a distribution substation and the input terminal of distribution primary circuits

electric meter—a device that measures the amount of power consumed, typically in kilowatt-hours (kWh)

electric power distribution systems—interconnected groups of electric distribution lines and associated equipment for transferring electric energy from points where it is transformed for delivery over the distribution system lines to consumers

electric power distribution—the movement of electrical energy from distribution substations to end-use customers

ground wires—wires that are installed to span the entire length of a utility pole and into the ground that provide a safe path for unintended power to travel away from the distribution system components and into the ground

insulator—material such as glass or fiberglass that does not allow electrical current to flow through it; in electric power distribution, insulator also refers to the actual piece of equipment that is used to attach distribution lines that support the conductor and at other conductor attachment points

interconnected distribution networks—a type of distribution network that consists of a system of distribution lines that are connected to multiple power sources

kilowatt-hour (kWh)—a unit signifying 1,000 watts of electricity used in 1 hour; used for customer billing

load—the amount of electric power required by consumers (demand)

primary circuit—the distribution circuit that carries electrical power from a substation to a local distribution service area

radial distribution networks—a type of distribution network that consists of a system of distribution lines that are connected to only a single power source

regulators—pieces of equipment used in electric power distribution systems that assist in regulating voltage in distribution lines

resistance—a measure of the degree to which an electrical component opposes the passage of current; resistance is measured in ohms

right of ways (ROWs)—the land set aside solely for the use of distribution towers or poles, lines, and other facilities; right of ways serve as safety mechanisms to maintain clearance areas between the distribution lines and surrounding structures or trees and other vegetation

service drop—common name for the distribution lines or wires that connect a distribution transformer to a customer’s house or place of business

step-down transformers—transformers that have more turns in the primary winding than in the secondary winding; voltages are higher in the primary circuit than in the secondary circuit

step-down—conversion of high-voltage electricity to lower voltage through the use of transformers at power substations

substations—locations along a transmission or distribution route containing equipment to transform and route power

subtransmission—the transfer of stepped-down voltage from the transmission system to the distribution system

subtransmission systems—subsystems of the electric power transmission system that carry voltages that are reduced from the major transmission-line system that is typically routed to distribution stations

switching stations—also known as switchyards, which are the areas at a generating station that transform and route power to be entered into the transmission system

telemetry—the wireless automatic transmission of data, usually for the purpose of remote monitoring

transformers—devices that transfer power from one circuit to another; step-up transformers increase voltage from the primary to the secondary circuit while lowering current proportionally, while step-down transformers lower voltage from the primary to the secondary circuit while raising current proportionally

voltage (volts)—the difference in electrical potential between any two conductors or between a conductor and ground; it is a measure of the electric energy per electron that electrons can acquire and/or give up as they move between the two conductors

wye—a method of wiring for a three-phase connection in which all three phases are connected to a common point, usually an electrical ground; when drawn in a line diagram, the shape resembles a "Y"

Unit A References

Siemens. Planning of Electrical Power Distribution. Technical Report. (2016). Erlangen, Germany

How to Read Your Electric Meter
http://www.bounceenergy.com/texas/choice-education/how-to-read-your-electric-meter

Naval Facilities Engineering Command. Electric Power Distribution Systems Operations. (1990). Alexandria, VA. https://www.wbdg.org/FFC/NAVFAC/OPER/mo201.pdf

OSHA. Illustration Glossary: Substations.
https://www.osha.gov/SLTC/etools/electric_power/illustrated_glossary/substation.html

Public Service Electric and Gas (PSE&G). (2003). Introduction to the Energy Utility Industry course.

Public Utilities Reports Guide. (2008). Delivery of Service. Public Utility Reports, Inc.

Reading an Electric Meter
http://www.sdge.com/smartmeter/readMeter.shtml

U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability. (2008). The Smart Grid: An Introduction. (2008). Washington, D.C.

Unit A Photo Credits

Photos used with permission from Centers for Disease Control and Prevention, Composite Technology Corp., Idaho National Laboratory, Idaho Power, Ildar Sagdejev, Minnesota House of Representatives Public Information Services, National Renewable Energy Laboratory, Occupational Safety and Health Administration, Oncor, Rural Electric Convenience Cooperative, and the U.S. Department of Energy.

Unit B: Distribution Governance, Stability, and Emerging Technologies

UNIT B: DISTRIBUTION GOVERNANCE, STABILITY, AND EMERGING TECHNOLOGIES

The National Electricity System

As mentioned in Module 1, the United States electric power system is an integrated system of interconnecting networks composed of generating plants, transmission facilities and lines, and local distribution facilities and lines. Generation, transmission, and distribution entities must work in a cooperative manner to provide reliable, adequate, and safe power to customers.

Module 4 discussed the national electricity grid and how more than 200,000 miles of high-voltage transmission lines in the United States move electric power from generating plants to local distribution systems to be sent to customers. Distribution networks have been created to reach customers all over the country to provide electrical power.

Distribution System Ownership

Who owns the electric power distribution? Just like the electric power transmission system, many organizations and entities have owners of different parts of the distribution system.

Electric power distribution systems are essentially co-owned by many groups and entities. Distribution ownership can be categorized in the following groups:

- **Fully Integrated, Investor-Owned Utilities**—entities that have ownership of generating plants, transmission systems, and distribution systems.
- **Transmission/Distribution Owners**—entities that only have ownership of transmission and distribution systems, but no generating plants.
- **Distribution Owners**—entities that only have ownership of distribution systems, but no transmission or generating plants.
- **Miscellaneous**—other miscellaneous groups such as consumer-owned or publicly-owned companies have varying ownership structures and may even pool their resources to jointly create larger organizations.

Did you know?

Your Electric Bill

The cost of electricity distribution in comparison to generation is comparatively low.

In a typical electric bill, distribution and transmission costs represent about 43 percent of a customer's electric bill, while generation accounts for about 57 percent.

U.S. Energy Information Administration, 2016

Distribution System Governance

Since the distribution system essentially serves as the last stop in the delivery of electrical power to consumers, 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.

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.

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

Distribution System Security and Reliability

The creation and maintenance of a distribution network that provides the continued safe and reliable delivery of electrical power to all customers requires substantial infrastructure investment.

Similar to the transmission system, distribution networks must maintain proper and sufficient operations in order to provide a safe and adequate electrical power supply.

Distribution Outages

Distribution systems do not necessarily have the same level of redundancy as the transmission system possesses that provides increased system reliability. If a distribution network is out of service due to maintenance, repairs, or other factors, electrical power cannot be rerouted through another distribution network.

Since distribution networks provide power to smaller service areas compared to the transmission system, when a distribution network experiences an outage, it typically affects service to a smaller, localized area or community.

Focus on ...

Advanced Distribution Technologies

Supervisory Control and Data Acquisition (SCADA) Systems: Remotely monitor and control transmission and distribution systems.

Advanced Metering Systems: Bidirectional power monitoring abilities, multiple day/time/rate monitoring capabilities, and communication abilities.

Similar to the transmission system, the distribution system experiences both planned and unplanned service outages.

Scheduled Outages

A **scheduled outage** is a planned outage that occurs when a portion of a power system is shut down intentionally. Scheduled outages differ from other power outages in that they are usually planned and announced well in advance. Scheduled distribution line outages are typically preplanned for activities such as routine maintenance, improvements, or repair. Most distribution networks attempt to plan outages to have a minimal impact on customers.

Unplanned Outages

An **unplanned outage** is an interruption or failure of electrical service that is unintentional and unexpected. Unplanned outages can be caused by operation errors, line overload, equipment failure, and severe weather.

Emerging Technologies

The electricity utility industry is facing the challenges of rising consumer demand and an aging infrastructure. The costs of new construction and improvements to the national electricity system are increasing along with consumer demand for better service and technology.

New construction and upgrades will be needed to maintain system integrity. Just as with the national transmission system, emerging technologies are being sought to keep the national power grid, including local power distribution, working efficiently and smoothly.

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.

Did you know?

Distribution Technology in Hawaii

Emerging distribution technologies were piloted in the state of Hawaii.

An integrated energy management system was developed that allowed for advanced home energy management by consumers in addition to improved distribution operations.

This integration allows smart meters to communicate with home appliances to enable automated control while enhancing energy conservation through enhanced demand response practices.

Hawaii Natural Energy Institute, 2016

Distributed Generation

<u>Distributed generation</u> is electrical generation and storage performed by a variety of small, grid-connected devices. Examples include small hydro, biomass, biogas, solar power, wind power, fuel cells, and geothermal power, which increasingly play an important role for the electric power distribution system. These power sources typically support a single user, such as a small industrial plant, agriculture operation, or even small communities. These systems are often connected to the electric power grid and can provide excess power to the grid. In addition, they can supply electric power to the primary user during widespread power outages. Technologies have been developed to allow these distributed energy sources to operate while connected to the grid without causing interconnection problems. For example, during a widespread power outage, automated equipment will disconnect the distributed energy source from the power grid to protect workers repairing the power distribution system from the distributed electrical energy.

Monitoring and Control Technology

Advanced Metering Systems

As mentioned earlier in this module, electric metering technologies are being updated to provide advanced bidirectional 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.

☼ ACTIVITY: Advanced Metering Systems

Advanced metering systems can provide accurate and detailed information to both consumers and providers that can help make energy-saving decisions. Make a list of different ways that advanced metering systems could be used to help encourage energy-saving behaviors. Do you currently use any of these energy-saving measures in your home or place of business?

Supervisory Control Systems

New advanced supervisory control equipment and systems allow for more advanced remote control of system components. Coupled with increased accuracy from newer metering technologies, advanced control systems provide an improved interface for real-time, data-driven decision-making and **demand response**. Advanced power monitoring and control help customers and providers benefit from customized services. In addition to customized control, the increased supervisory capabilities provide continuous system analysis ensuring proper operations and better overall system security.

Did you know?

Phantom Power

Many household appliances are never fully switched off but spend most of the time in a standby mode. The power that is consumed by these appliances when turned "off" is commonly called "phantom power."

Phantom power from multiple appliances and devices in a single household can add up to a significant amount of power usage.

Smart Grid

As mentioned in Module 4, of all the technologies aimed at the improvement of the electric power system, perhaps the most commonly recognized is the creation of the **smart grid**. Multiple emerging technologies are being collectively pooled to develop a dynamic and reactive smart power grid system.

The concept of the smart grid is envisioned as a dynamic and interoperable system involving the entire national electricity grid that delivers accurate and useful information and control options for customers, distributors, and grid operators, for the purpose of collectively reducing system demands and costs, detecting and intuitively fixing problems, and increasing energy efficiency.

The government has pledged funds to aid in the creation of a smart grid, and the transformation of the current system has already begun. It is estimated that the full smart grid transformation will take 20 to 25 years to complete.

Focus on ...

Smart Grid – Key Components

- Reliable
- Secure
- Efficient
- Flexible
- Responsive
- Intuitive

The Smart Grid and Distribution

The new smart grid will affect all parts of the national electricity system—generation, transmission, and distribution. Smart grid technology provides many possible benefits for the electric power distribution systems. For example, it will enable real-time acquisition of energy use data and provide feedback to customers. The most familiar implementation of smart grid technology in the distribution system is the installation of new **smart meters**.

As mentioned earlier, smart meters can help improve the distribution system by improving sensing, measurement, and control technologies. New smart meters will allow distribution system controllers to monitor power quality and to better detect and correct system anomalies. On the consumer side, enhanced smart grid technologies in the distribution system will help consumers be better informed about power consumption activities and will also provide them with opportunities to actually apply that new knowledge in good use practices and demand response control choices.

Focus on ...

Smart Grid and Distribution

- More efficient distribution
- Intuitive response to changes in conditions
- Real-time customer energy use feedback

SmartGrid.gov, 2017

☼ ACTIVITY: Smart Meters

While smart meters have an important role in the establishment of a smart grid system, they have been met with a mixed reception. Some customers welcome the advancement in metering technology while others have been apprehensive about their installation and use.

Hold a class debate regarding the use of smart meters. With the class divided into two groups, each group should research and represent one side of the debate: the benefits of smart meters vs. concerns regarding their use.

Smart meter technology that employs enhanced communication technology is referred to as **Advanced Metering Infrastructure** (AMI). Advanced metering infrastructure activities are being implemented on a national scale on a daily basis. This technology enhances the two-way communication of electrical power use information. Increased accuracy of power usage information provided to customers can help them change usage behaviors and better operate future “smart appliances” or “smart systems” in their homes.

Did you know?

Meter Accuracy

All meters, whether traditional mechanical meters or newer digital meters, are required to meet the same standards for meter accuracy and operation before installation.

Smart grid technologies being applied in the distribution system are adding efficiency and reliability to the national grid.

☼ ACTIVITY: Advanced Metering Infrastructure

Contact your local utility company and ask for information regarding their current involvement in advanced metering technologies. If they are not currently utilizing any AMI technologies, find out what their plans are for possible future developments in that area.

Focus on ...

Smart Meter Benefits

- Better access to data to manage energy consumption
- More accurate and timely billing
- Improved rate/pricing options
- Improved detection of meter tampering/theft
- Reduced estimated billing errors
- Improved data for overall efficient grid operation

Edison Electric Institute, 2011

Unit B Glossary

advanced metering infrastructure (AMI)—smart meter technology systems that employ enhanced communication technologies that automatically measure and report power usage information

demand response—mechanisms or systems that enable the strategic management of electricity consumption (demand) in response to supply conditions; demand response systems can enable customers to take advantage of lower energy prices while improving the reliability of the grid

distributed generation—electrical generation and storage performed by a variety of small, grid-connected devices.

scheduled outage—when a portion of a power system is intentionally shut down, usually to allow for maintenance or other preplanned activities

smart grid—modernization of the current grid technology; has the ability to monitor energy flow and communicate data back to utility companies; uses smart meters; participates in distributed generation allowing smaller power sources to feed energy back into the grid; stores energy generated in off-peak hours and distributes it during peak hours

smart meters—specialized electric power meters that measure the amount of power consumed and have the ability to communicate information between the meter and a central communication system

Supervisory Control and Data Acquisition (SCADA)—a system of remote assessment used to monitor and control the electric transmission system

unplanned outage—an interruption or failure of electrical service that is unintentional and unexpected

Unit B References

Edison Electric Institute. (2011). Smart Meters and Smart Meter Systems, A Metering Industry Perspective; An EEI-AEIC-UTC White Paper.

Natural Energy Institute. Analysis of Smart Grid Technologies. (2016). http://www.hnei.hawaii.edu/sites/www.hnei.hawaii.edu/files/Analysis%20of%20Smart%20Grid%20Technologies.pdf

Public Service Electric and Gas (PSE&G). (2003). Introduction to the Energy Utility Industry course.

Public Utilities Reports Guide. (2008). Delivery of Service. Public Utility Reports, Inc.

American Public Power Association. https://www.publicpower.org/policy/solar-distributed-generation

U.S. Department of Energy, Smartgrid.gov. http://smartgrid.gov

U.S. Departments of Homeland Security and Energy. (2007). Energy: Critical Infrastructure and Key Resources Sector-Specific Plan as Input to the National Infrastructure Protection Plan (Redacted). Arlington, VA.

U.S. Energy Information Agency, Major components of the U.S. average price of electricity. (2016).
https://www.eia.gov/energyexplained/index.cfm?page=electricity_factors_affecting_prices

Unit B Photo Credits

Photo used with permission from Edison Electric Institute.

Unit C: Natural Gas Distribution

UNIT C: NATURAL GAS DISTRIBUTION

Natural Gas Energy

Electric power lines aren't the only source of energy in homes and businesses. As you have learned in previous modules, natural gas can be used as a source of energy for electric power generation. Natural gas can also be used as a source of energy through direct combustion for cooking and heating.

As mentioned in Module 1, pure natural gas, like solid petroleum, is made up of the chemical elements hydrogen and carbon. Although natural gas is actually a mixture of several gases, it is largely made up of a gas called methane, which is the lightest hydrocarbon. This segment of the energy industry includes the exploration, extraction, processing, storage, transportation, and distribution of natural gas.

Natural Gas System Overview

The entire natural gas system starts with exploration and extraction of gas through wells. Once extracted from the ground, the gas moves through cleaning and treatment processing, and then to a compressor station or a storage field before being routed to a high-pressure transmission pipeline. Transmission pipelines utilize specialized regulators to reduce pressure for connections to high- and low-pressure **distribution mains**. Distribution mains connect to **street mains**, which branch out into **individual service connections** that run to a home or business. See Figure 5C.1.

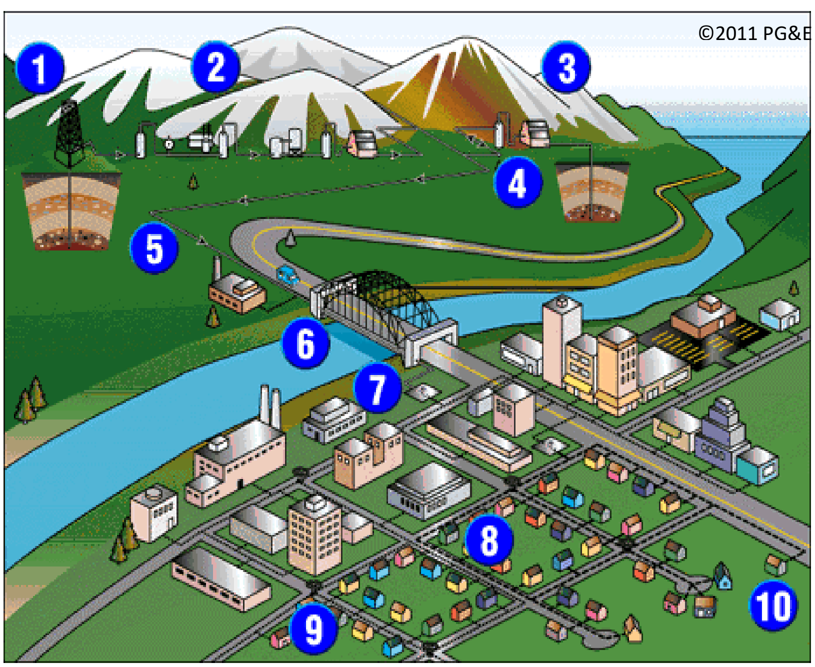


Figure 5C.1 Natural Gas System

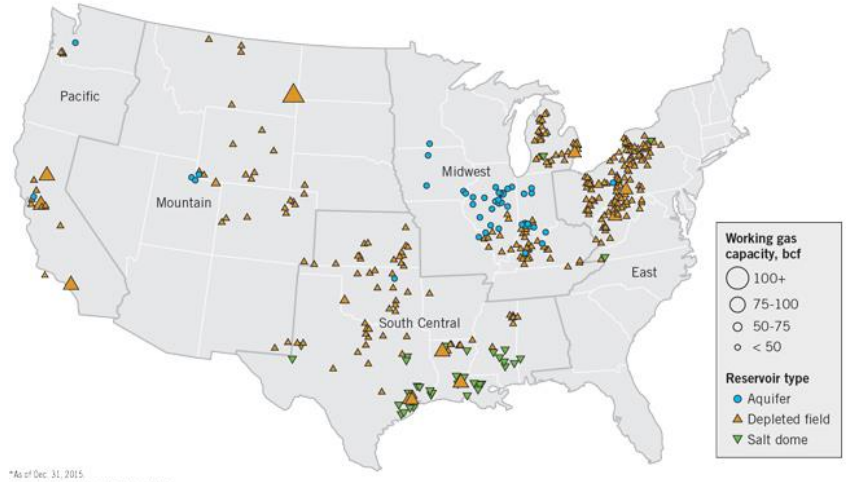
1. Gas wells
2. Gas cleaning and treatment
3. Compressor station
4. Gas storage field
5. High-pressure transmission lines
6. Suspended transmission lines
7. Regulators
8. High- and low-pressure distribution mains
9. Valves
10. Service connections

Natural Gas Procurement and Processing

Natural gas is typically procured through pumping of deep wells. Texas, Louisiana, Oklahoma, New Mexico, and Kansas have the majority of the natural gas source reserves in the United States.

Gas must be processed before it enters into long-distance pipelines. Raw gas from wells must go through cleaning to make it suitable for use in homes and factories. Natural gas may include two undesirable components: 1) sand, which can be removed at the wellhead, and 2) hydrogen sulfide, which may be removed before the gas is distributed. During processing, valuable by-products are recovered, such as light oils; natural gasoline; and other petroleum gases such as ethane, propane, and butane. As mentioned earlier in this text, since natural gas is odorless, a harmless but pungent odorizer, “mercaptan,” is added to the gas during processing as a safety precaution.

Natural Gas Storage



Because the demand for natural gas fluctuates with the seasons, it may not be needed right away. Reserves are injected into underground storage facilities such as depleted gas reservoirs, salt caverns, and aquifers. Three quarters of our national natural gas reserves are stored in depleted gas reservoirs. These consist of underground locations from which natural gas has already been extracted. Depleted gas reserves have two advantages—they’ve already shown that they can successfully contain natural gas, and they generally have a pipeline infrastructure associated with them. Salt caverns are created from underground salt domes by dissolving a large pocket or “cavern” in the dome with water. They are smaller than depleted gas reservoirs or aquifers. Aquifers are spaces underground that contain large amounts of water. They can be repurposed as storage areas for natural gas, but this is expensive.

Natural Gas Transmission and Distribution

As with electric power, once natural gas is procured and processed, it must travel through transmission and distribution networks to be delivered to customers. To carry gas from the places where it is produced to the places where it is needed, the natural gas industry has constructed hundreds of thousands of miles of large-diameter pipelines.

The U.S. natural gas pipeline network is similar to the electric power system in that it is a highly integrated grid-type network. The transportation of gas through the grid is possible to and from almost any location in the lower 48 states.

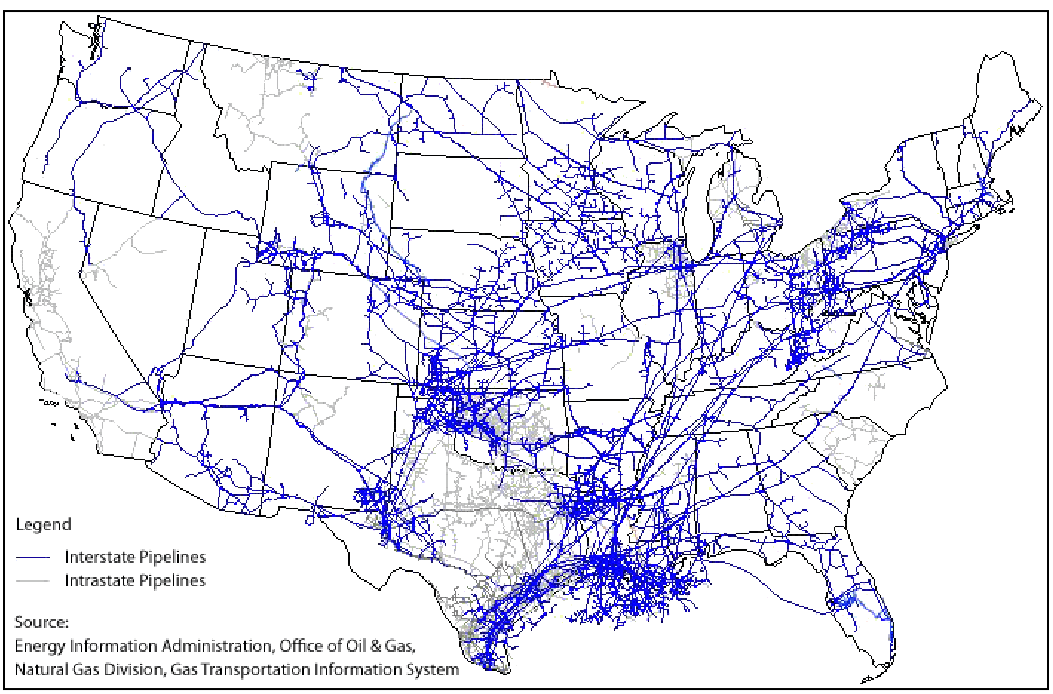
The movement of natural gas from its source to a customer's home meter involves several physical transfers and multiple processing steps. The natural gas grid is capable of meeting customer demand through the carefully planned interconnection of procurement and processing establishments, storage sites, and transmission and distribution pipelines.

Focus on ...

U.S. National Pipeline Grid

- More than 210 natural-gas pipeline systems.
- More than 305,000 miles of interstate and intrastate transmission pipelines.
- More than 1,400 compressor stations.
- More than 11,000 delivery points, 5,000 receipt points, and 1,400 interconnection points.
- More than 400 underground storage facilities.
- More than 49 locations for import/export via pipelines.

U.S. Energy Information Administration, 2017



Regional Transmission

After cleaning and processing, gas moves through pipelines to a compressor station or a gas storage field before being fed again into high-pressure transmission lines. High-pressure transmission pipelines consist of interstate and intrastate pipelines.

Interstate pipelines are long-distance, wide-diameter (20–42 inches), high-capacity pipelines that are responsible for transporting the vast majority of natural gas throughout the United States.

Intrastate pipelines operate within a state's borders and interconnect gas producers, local distributors, and the interstate network.

> **Did you know?**
>
> **Pipeline Safety and Security**
>
> The Office of Pipeline Safety ensures safety in the design, construction, operation, maintenance, and emergency response planning of the nation's pipelines.
>
> In accordance with the Federal Pipeline Safety Improvement Act of 2002, companies must develop and implement a transmission integrity management plan (IMP) that addresses the monitoring and maintenance of transmission pipelines for community safety.
>
> PG&E, 2011

Transmission pipelines may be buried or suspended to cross rivers or other obstructions. As natural gas travels through pipelines, some pressure is lost due to friction caused by the natural gas rubbing against the inside walls of the pipelines. The loss of pressure is compensated for at compressor stations located about every 50 to 100 miles along transmission pipelines.

Natural gas in a pipeline is pushed along at about 15 miles per hour. This means that on a 1,000-mile line, it takes about three days for gas to travel from the wellheads to the last customer. In winter, when more gas is needed for heating, the flow may be speeded by increasing the pressure in the line.

©2011 PG&E

Pipeline dispatchers can control the flow of gas throughout the length of the line. They can increase or decrease the pressure as needed and spot troubles at any point by signals returned to them through automatic control systems. They can then direct crews to correct any problems. Regulators on the transmission lines are adjusted to reduce pressure for high- and low-pressure distribution mains.

Pressure in the gas transmission system is constantly monitored and maintained at safe levels. Pressure-limiting stations control pressure at critical points by limiting the pressure in lines regardless of how the demand or supply changes. Line-rupture control valves are also installed on pipelines to avoid excessive loss of gas when a line break occurs.

Supervisory Control and Data Acquisition (SCADA) system technologies, similar to those used in electric power transmission and distribution systems, are also used in gas transmission and distribution systems. The systems collect and use automated data to monitor and control the flow of gas through transmission and distribution pipelines.

☼ CAREER PROFILE: Corrosion/Cathodic Protection Technician

Julie S. works as a corrosion technician for a large, multistate natural gas company. Her job takes her around the country as well as offshore. "My job is to inspect pipelines for signs of degradation. Over time, they can be worn away by many environmental factors, and we have methods for protecting them, but they are not 100 percent effective," explains Julie. "Sometimes the corrosion is on the outside; sometimes it's on the inside."

Her job requires her to collect, record, and analyze historical and current data and new critical information in order to monitor and correct the cathodic protection system's performance. Julie's two-year degree in electrical engineering technologies gave her the background knowledge for working with a complex electrical system. Her coursework also included topics such as the basis of materials science and electrochemistry.

Since her graduation, Julie has worked in the natural gas industry for five years. This year she will be taking the Corrosion Society (formerly the National Association of Corrosion Engineers) course on internal corrosion and the certification test.

Science Connections

A Closer Look at Corrosion

Corrosion refers to the wearing away of metal that takes place through a chemical reaction. Rust is a familiar example. When iron is exposed to water and oxygen, it undergoes a process in which the iron (Fe) has its electrons stripped away, and it becomes iron oxide (Fe++). Iron oxide is the common name for rust. Thinking about the rust that you've seen—with the metal crumbling into orange flakes—you can see how corrosion would be a problem for large metal structures such as pipelines or offshore drilling rigs.

Corrosion can be controlled by applying a noncorrosive coating to the metal surface and by using cathodic protection equipment. One method of cathodic protection involves connecting metals that are more likely to corrode (more electrochemically active) to the metal that needs to be protected. Metal can also be protected by a flow of DC power.


©2011 FERC

Local Distribution

The natural-gas distribution system consists of high-pressure distribution mains, semi-high-pressure distribution mains, and low-pressure distribution mains. Operating pressures are regulated from 60 psi down through 25 psi to less than 1 psi for final delivery to a customer.

☼ CAREER PROFILE: Gas Distribution Technician

811 Know what's below. Call before you dig.

Howard K. has been a gas distribution technician for ten years. "I got here through an apprenticeship," he notes. "And I recommend that career path to others who want to get into this industry." Howard is responsible for the maintenance and operation of distribution mains. He also works closely with construction and excavation crews to find, locate, and mark pipeline locations before digging. In cases of large main breaks, he coordinates his efforts with local officials to ensure public safety. He's also on a rotating schedule to respond to the One-Call 8-1-1 system. By law, you must call before you dig—giving the utility enough time to mark your property. (State laws vary from 48 to 72 hours, most excluding weekends and legal holidays.)

© Common Ground Alliance

Community Connections

Have you seen these flags?
A gas distribution technician will mark various underground utility locations with flags color-coded to indicate the type of service.

- •Red–Electric
- •Orange–Communications, Telephone/CATV
- •Blue–Potable Water
- •Green–Sewer/Drainage
- •Yellow–Gas/Petroleum Pipe Line
- •Purple–Reclaimed Water
- •White–Premark site of intended excavation

U.S. Department of Transportation, Pipelines and Hazardous Materials Safety Division

Regional transmission pipelines connect to lower-pressure distribution mains that connect to local valves. A "**city gate station**" is the term used for the location at which a local gas company receives natural gas from long-distance pipelines. Large cities may have multiple gate stations. These are the connection points where the transmission pipeline network joins a local gas company's system of underground piping, the local distribution system.

Focus on ...

Essential City Gate Functions

- Cleaning of incoming gas to remove any impurities that may have been picked up during transport in transmission pipelines.
- Reduction of pressure to lower levels suitable for the local distribution system.
- Measurement of gas received through the transmission network.
- Addition of chemical odorant for safety purposes.

PG&E, 2011

☼ CAREER PROFILE: Metering and Regulating Technician

Jorge Y. is a metering and regulating (M&R) technician for a municipal utility. It's his job to maintain the city gate, a vital part of the natural gas distribution system. He installs, operates, and maintains odorizers and meters; calibrates instruments; checks on delivery pressure in the pipelines and operation of all valves; and makes corrections or repairs where needed. Jorge enjoys his job because, "It's both mechanical and technical. I get to work with my hands, but I also have to know math for calculating the volume of gas flow to customers and understand computers for some of the automated functions."

Before working as an M&R technician, Jorge worked as a service technician. His job experience made him want to know more, so he enrolled in and completed a year-long certificate program at a nearby college. He uses his skills and knowledge to ensure that an adequate flow of natural gas to customers is maintained.

After passing through the city gate station, the gas enters the underground network of pipes of the local distribution system. Pipes carry the gas under the streets to buildings in the community. Many gas mains are made of cast iron. In recent years, steel pipe has been used in the construction of new mains and for replacement of old piping. Steel pipe is coated with various kinds of rustproof materials to enhance the longevity of its service life.

Local gas distribution systems are divided into sections. Each section can be shut off by closing a valve in the street main. These local valves provide a way to isolate sections of a main for maintenance, repair, or in emergency situations. Individual service connections branch off of the street main and are attached to each home or business.

Did you know?

Distribution Pipelines

There are over 2 million miles of city mains and service pipelines in the U.S.

U.S. Department of Transportation, 2011

☼ ACTIVITY: Pipeline Construction, Design and Components

Research how materials and processes have changed for the design, manufacturing, and construction of pipeline systems.

What variables in materials (iron, steel, plastic) and design (safety and control features such as sectional design and valves) affect quality assurance factors in pipeline transportation systems?

Individual Service Connections

The individual service connections, commonly called “service pipes” or “gas services,” are the pipes that connect the distribution mains to a customer. These service pipes are usually 1 or 2 inches in diameter. The service pipe extends from the street main underground to a home gas meter. Service regulators located at a customer’s meter reduce the gas pressure to a lower standard delivery pressure.

Gas Meters

Gas flows through a meter into the pipes in a home to supply the oven, cooktop, water heater, home-heating furnace or boiler, and other gas appliances.

Service shut-off valves are located at a customer’s meter and can be used to turn off the supply of gas to a house in the event of an emergency.

Did you know?

Meter Capacity

Gas meter manufacturers are utilizing new materials and designs to produce smaller, more accurate, and longer lasting meters.

New smaller meters have about the same capacity as the lungs of an average man.

When a man breathes normally, he inhales about 1/10 to 1/7 of a cubic foot of air. If he inhales at the normal rate of 14 times a minute, he is taking in about 80 to 120 cubic feet of air an hour, which is much the same capacity as a small gas meter.

PG&E, 2011

☼ CAREER PROFILE: Gas Service Technician—Emergency Response

As with many of the jobs in the utility industry, communication is key to Shelly R.'s success as a "first responder" to potential gas emergencies. "I'm called out, sometimes in the middle of the night if I'm on rotation for that time, when customers believe they smell a gas leak. My first task is to arrive quickly and make sure the building's residents are safe. If it's a family home, they may be scared. The dispatcher may have asked them to leave the premises and to wait for me to arrive to investigate the fumes. I have to be calm and professional and verify what they told the dispatcher."

As a gas service technician, Shelly uses equipment to detect leaks indoors and outdoors, inspects service lines and house lines, performs pressure checks, shuts off gas service if necessary, and restores service when the problem is corrected. Under less routine or more hazardous situations, she may need to establish immediate contact with her supervisor or with local authorities such as the fire department.

"The bottom line is safety," says Shelly. "A gas leak has the potential to be deadly. Our company has technicians on-call 24/7 who can make it out to a site within an hour or less. My job is to get there, troubleshoot the situation, and make repairs or make the location safe so that the problem can be remedied asap."

New Metering Technology

Innovations in gas metering include the use of advanced, electronic meter-reading systems. These systems allow for the remote transfer of meter information.

☼ ACTIVITY: Comparing Advanced Metering Technology

Compare and contrast the technology advancements in electric power metering and natural gas metering.

Has one industry experienced more technological advancements over the other? What factors have led to advancements in both of the industries?

☼ CAREER PROFILE: Gas Service Technician—Operations and Maintenance

Sal Q. is a gas service technician called out for routine, nonemergency situations. "It may not technically be an emergency," says Sal, "but a furnace that goes out in the middle of winter feels like an emergency to my customers. I'm glad to be able to help them." A typical day may involve installing gas meters and service regulators; installing new appliances such as ovens, dryers, and hot water heaters; testing pipeline connections for gas pressure and flow; and repairing worn or defective parts.

Unit C Glossary

city gate station—the physical location and facilities where a local gas distribution company receives natural gas from long-distance transmission pipelines

distribution main—pipelines that supply local service areas; distribution mains connect city gate stations to street mains

individual service connection—also commonly called "service pipe" or "gas services"; these are the pipes that connect the distribution mains to a customer's home meter

interstate pipelines—long-distance, wide-diameter, high-capacity pipelines that are responsible for transporting the vast majority of natural gas throughout the United States

intrastate pipelines—transmission pipelines that operate within a state's borders and interconnect gas producers, local distributors, and the interstate network

street main—pipelines that connect distribution mains to individual service connections

Unit C References

Bushman, J. Impressed Current Cathodic Protection Design. Bushman & Associate, Medina, Ohio. http://www.bushman.cc/pdf/impressed_current_system_design.pdf

Common Ground Alliance
http://www.call811.com

Natural Gas Supply Association
http://www.naturalgas.org/

Pacific Gas and Electric (PG&E). Power Pathway: Gas System Overview.

Pipeline 101: Introduction to Pipelines
http://www.pipeline101.org/

Public Service Electric and Gas (PSE&G). (2003). Introduction to the Energy Utility Industry course.

Public Utilities Reports Guide. (2008). Delivery of Service. Public Utility Reports, Inc.

The Corrosion Society
http://www.nace.org

U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration
http://phmsa.dot.gov/

U.S. Energy Information Administration (EIA)–Natural Gas
http://www.eia.gov/naturalgas/

Unit C Photo Credits

Photos used with permission from Argonne National Laboratory, Centers for Disease Control and Prevention, Common Ground Alliance, Federal Energy Reliability Committee, Pacific Gas and Electric, and the U.S. Energy Information Agency—Office of Oil and Gas.