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United States Electricity Industry Primer

Office of Electricity Delivery and Energy Reliability

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ACKNOWLEDGMENTS

This report was prepared by the Office of Electricity Delivery and Energy Reliability under the direction of Patricia Hoffman, Assistant Secretary, and Devon Streit, Deputy Assistant Secretary.

Specific questions about information in this report may be directed to Jamie Clark, Infrastructure Systems Analyst (Jamie.Clark@hq.doe.gov).

Contributors include Matthew Gilstrap, Shravan Amin, and Kevin DeCorla-Souza.

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1 INDUSTRY OVERVIEW

The electric power industry is the backbone of America's economic sectors, generating the energy that empowers its people and businesses in global commerce. Transportation, water, emergency services, telecommunications, and manufacturing represent only a few of the power grid's critical downstream dependencies. Reliance on the electric grid is a key interdependency (and vulnerability) amongst all *Critical Infrastructure and Key Resource* (CIKR) sectors, plus supporting infrastructures, making grid reliability and resilience a fundamental need for national safety and security.

The United States has one of the world's most reliable, affordable, and increasingly clean electric systems, but it faces significant vulnerabilities with respect to physical threats from severe weather, terrorist attacks, and cyber threats. The popular transition to *smart*, data-driven technologies aims to increase power grid efficiency and engage customer reliability roles, but has been introduced at an unprecedented rate relative to the history of the industry, and injects uncertainty into grid operations, traditional regulatory structures, and utility business models—which have been successful over the past century and a half.

Electric power was first generated, sold, and distributed to urban customers in the 1870s and 1880s. Similar to modern-day *distributed generation*, electricity was generated locally in small power plants and distributed via direct current (DC) circuits, as opposed to the alternating current (AC) generation, transmission, and distribution systems used today. As with modern-day operations, several voltage levels were distributed depending upon the customer's needs.

As demand for power spread geographically over time, DC power systems struggled to expand due to high costs of construction and operation. A more robust, cost-efficient system was needed to generate, transmit, and distribute power over long distances to other urban and rural areas. Toward the end of the 19th century, the industry entered a transition with construction of the first large AC generation station at Niagara Falls—which marked the first technology capable of inducing AC power to be transmitted over long-distance circuits. The construction of larger AC power stations became the commercially-viable solution for the development of a robust, national power grid, and eventually outpaced modular DC power systems.

Today, the U.S. electricity sector is influenced by a variety of new forces that have the potential to affect future management and operation of the grid. Current drivers include the growing use of less expensive natural gas for power generation, the retirement of coal and fuel oil generation for carbon reduction, uncertainty in the long-term role for nuclear generation, rapid deployment of intermittent renewable energy technologies, evolution of load types and reduced load growth, severe weather, and growing jurisdictional interactions at Federal, State, and local levels.

The private sector, States, and Federal Government all play crucial roles in ensuring that electricity infrastructure is reliable, resilient, and secure. This document will provide a baseline for understanding important topics in each division of the electric power supply chain; examine vulnerabilities to the grid; discuss regulatory and ownership structures; and offer context for causes of power outages and response efforts during emergencies.

2 ELECTRICITY BASICS

Most Americans understand that electricity is sent from a power plant over power lines, but cannot describe specifically how it is generated or how its properties are manipulated in order to be delivered to customers. Electrical energy, including electrical potential, or circuit voltage, is actually neither created nor destroyed, but transformed from mechanical work at a power generating station. This occurs through electromagnetic induction, a process that was discovered by Michael Faraday in 1831. Faraday found that current and voltage in a circuit were spontaneously induced in the presence of a changing magnetic field. Modern electric generators utilize turbine engines to spin or rotate magnets around coils of conductive wiring to induce alternating currents and voltages capable of performing work over time, which is also known as power.

Electrical power is the instantaneous flow of electrical charges, or currents, which serve as the means to perform work. Currents are driven by an electromotive force, or voltage, which represents the driving potential for performing work. Contemplate the water wheel analogy: in the old days, waterwheels provided mechanical power from the potential energy in a flowing body of water, the river, or current in this case. In this imaginary circuit, the pressure of the flowing water drives the waterwheel; the fluid itself provides the weight, or force, used to perform mechanical work on the wheel. Together, mechanical power is generated from the repetitive forces exerted on the drive shaft from the rotating wheel. In an electric circuit, power is equal to the product of the voltage and current, or $P = IV$.

Figure 1: Basic Electricity Definitions

Basic Electricity Definitions

- **Current, *I*:** the flow rate of charge; measured in Amperes, *A*
- **Voltage, *V*:** the electromotive force, or electrical pressure applied to electrons, forcing flow of charge through the circuit, or path; measured in Volts, *V*
- **Energy, *E*:** stored work; measured in Joules, *J*
- **Power, *P*:** the rate at which energy changes form or location. It is the work performed, or energy conversion, in a unit of time; measured in Watts = Joules/second, *W*

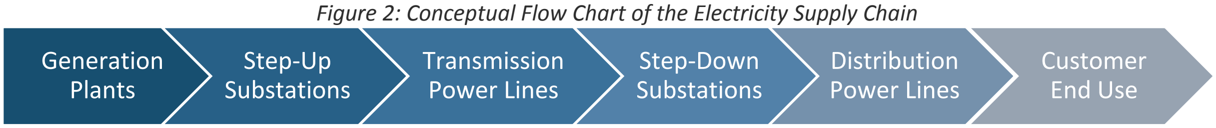
Source: U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability

Electrical power flow is instantaneous and finite. Commercially viable storage options do not currently exist. The flow of electricity is governed by electromagnetic properties of the materials that make up the electric grid. Circuits are constructed to establish a path for power to flow, and flow can be controlled in a system using protective elements such as fuses, breakers, relays, and capacitors. The following sections will dive deeper into the processes for delivering electricity, explore the regulatory and private entities that operate the grid and ensure its reliability, and examine vulnerabilities and response efforts that take place during energy emergencies.

3 ELECTRICITY SUPPLY CHAIN

The structure of electricity delivery can be categorized into three functions: generation, transmission, and distribution, all of which are linked through key assets known as substations. Even though power infrastructure is highly redundant and resilient, customer outages do occur as a result of system disruptions.

Figure 2: Conceptual Flow Chart of the Electricity Supply Chain



3.1 GENERATION

Number, Capacity, and Fuel Mix

In 2014 there were 19,023 individual, commercial generators at 6,997 operational power plants in the United States. A power plant can have one or more generators, and some generators have the ability to use more than one type of fuel. Power supply in the United States is generated from a diverse fuel mix. In 2014, fossil fuels like coal, natural gas, and petroleum liquids accounted for 67 percent of U.S. electricity generation and 89 percent of installed capacity.

Figure 3: U.S. Power Generation by Fuel Type in 2014

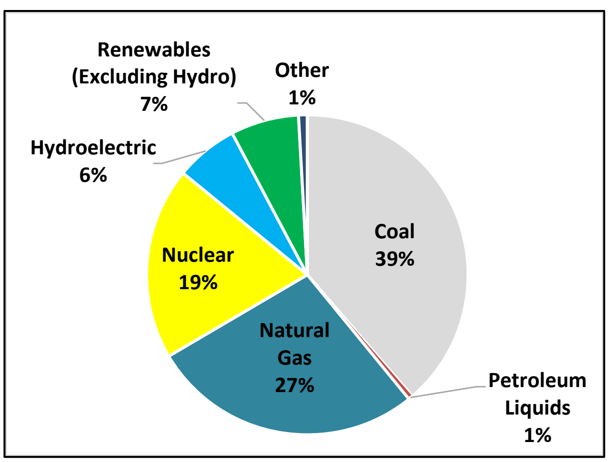
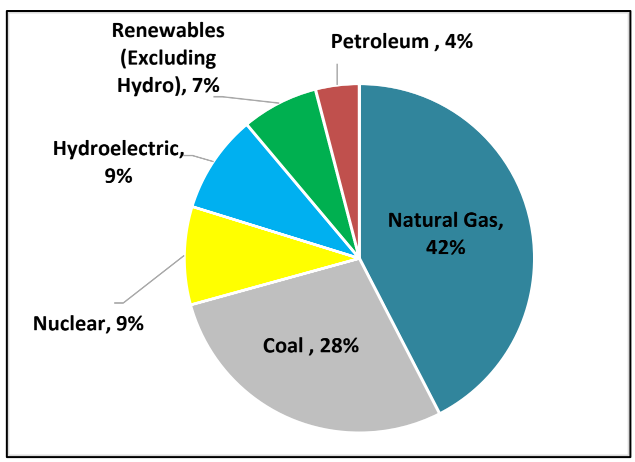


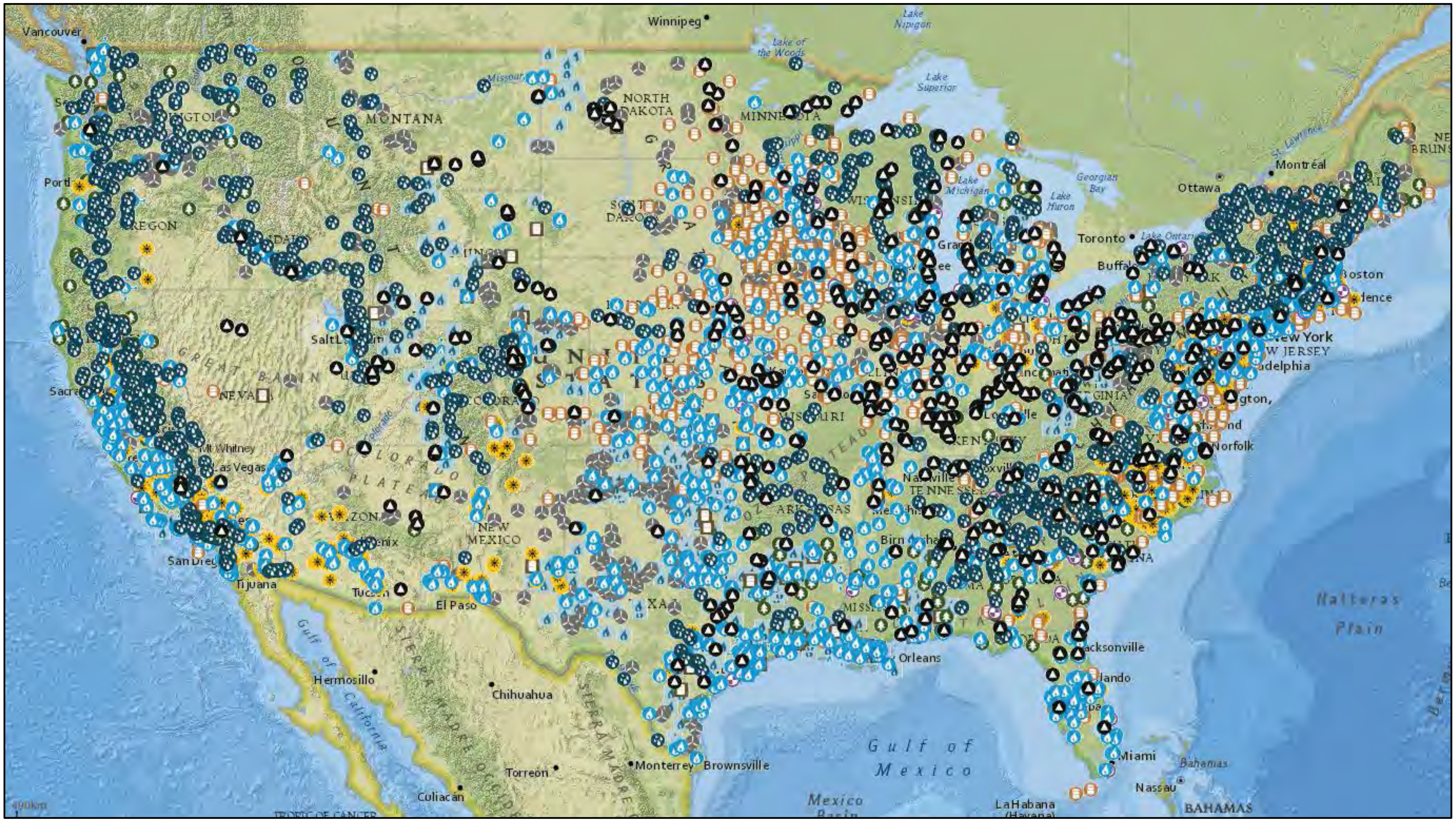
Figure 4: U.S. Generation Capacity in 2013



Sources: U.S. Department of Energy, Energy Information Administration (EIA)

Generation capacity also varies by State and can be dependent upon the availability of the fuel resource. Coal and gas power plants are more common in the Midwest and Southeast whereas the West Coast is dependent upon high-capacity hydroelectric power as well as gas-fired power plants. Power generation fuels also have a supply chain of their own. Coal, natural gas, uranium, and oil must all be extracted, processed into useable fuels, and delivered to the generation facility. Vast infrastructure networks of railroads, pipelines, waterways, highways, and processing plants support the delivery of these resources to generating facilities, and many rely on electric power to operate.

Figure 5: Geographic Distribution of U.S. Power Plants (More than 1 Megawatt)



Source: U.S. Department of Energy, Energy Information Administration (EIA)
Energy Mapping Tool
Data: http://www.eia.gov/maps/layer_info-m.cfm

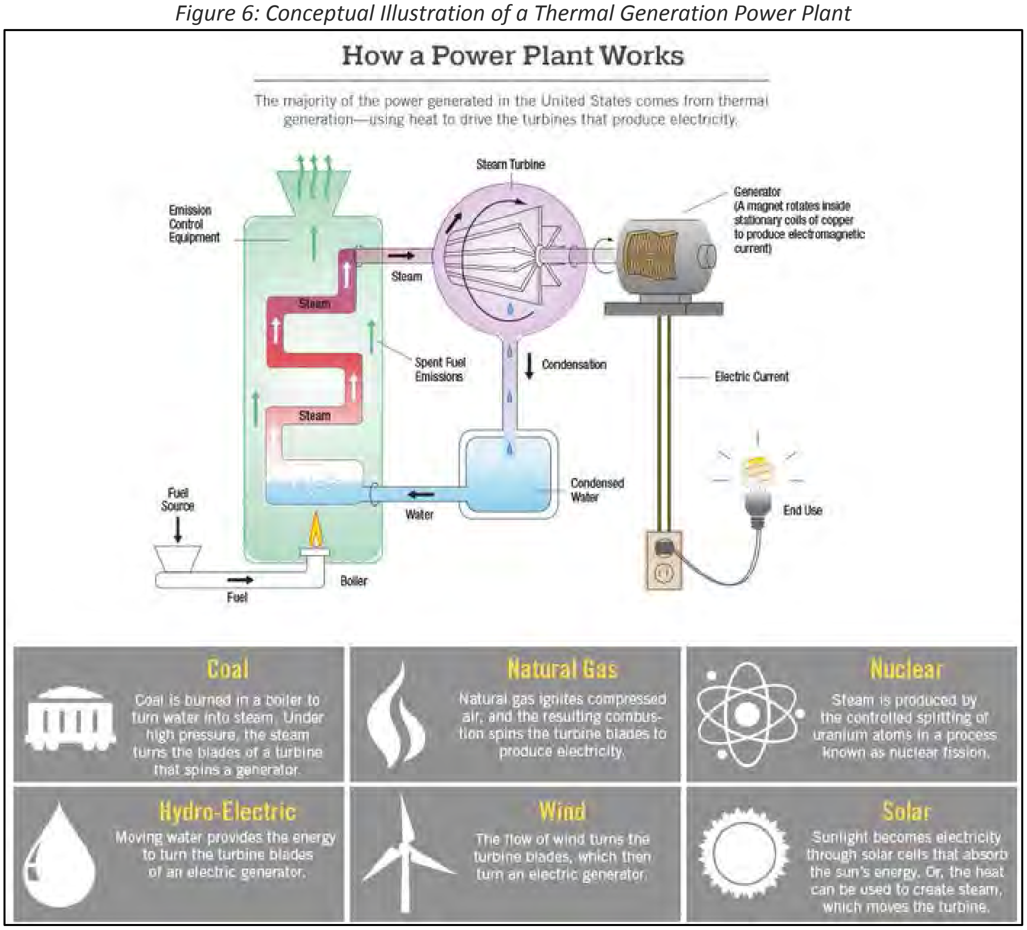
- Coal Power Plant
- Hydroelectric Power Plant
- Natural Gas Power Plant
- Nuclear Power Plant
- Petroleum Power Plant
- Solar Power Plant
- Wind Power Plant
- Wood Power Plant

How Does a Power Plant Work?

Electricity is a secondary power source harvested from the mechanical work that is exerted *from* a turbine *to* a coupled, rotary magnet that spins around copper coils within a generator. The purpose of the primary fuel's energy is to create mechanical power that can be transformed into electrical power. In the case of a three-phase AC generator, there are three windings that the magnets rotate around to induce three separate AC currents. The induced currents drive an electromotive force, and together produce power from the power plant. For more insight on alternating current and three-phase generators, refer to Appendix B.

The majority of turbine generators used are thermally driven by steam. In thermal generation, fuel is combusted to produce steam from which mechanical work is extracted as it releases energy through high-pressure condensation in a turbine. Coal, gas, nuclear, and petroleum power plants all utilize thermal power generation in combustion turbines. Sometimes these facilities also utilize waste heat to drive an additional turbine to increase the plant's thermal efficiency, known as combined cycle facilities. Thermally-reliant power plants are characterized by their thermal efficiency factor which compares the amount of energy produced to the amount that was consumed in the process. These factors typically range from 0.45 – 0.60, which becomes incorporated in the design of the plant.

Figure 6: Conceptual Illustration of a Thermal Generation Power Plant

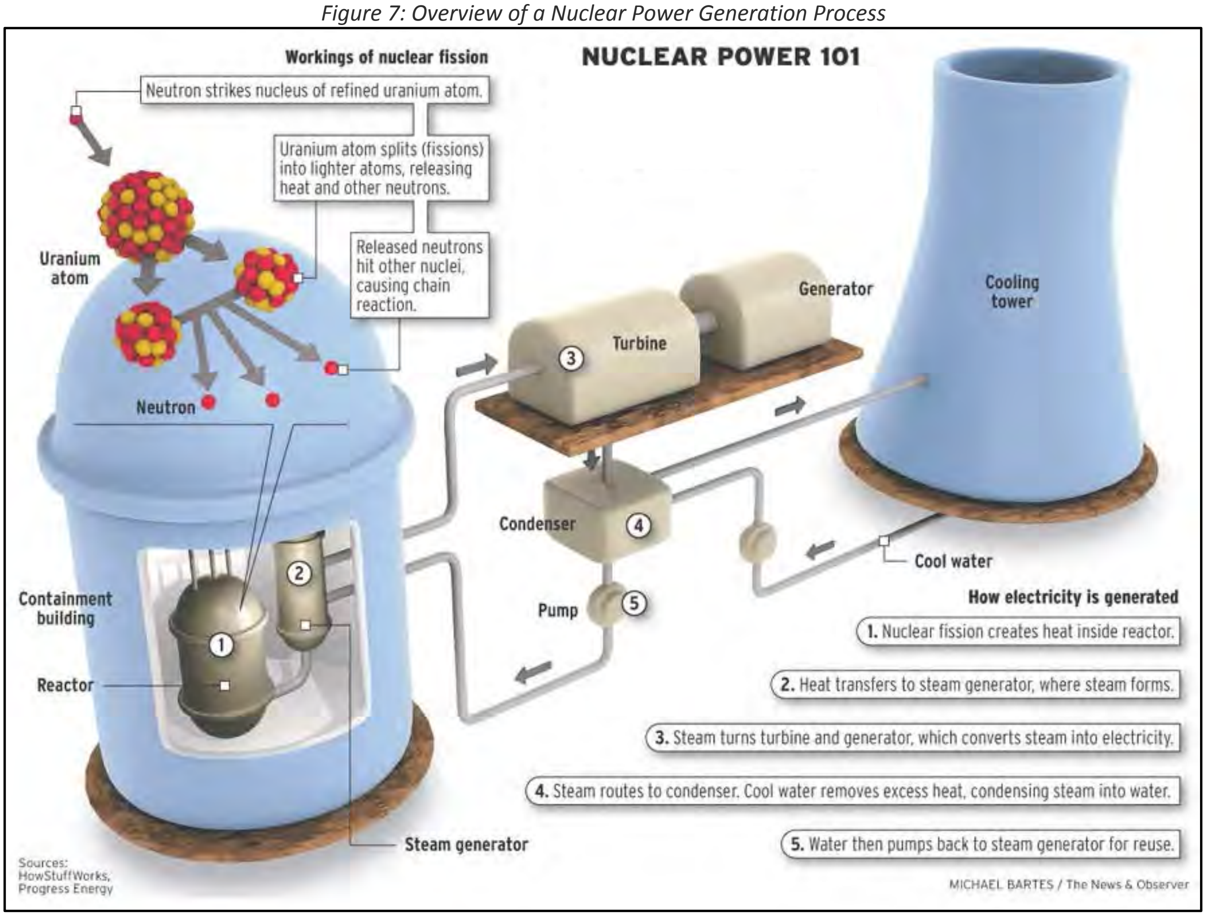


Source: Edison Electric Institute (EEI)

Nuclear Power Plants

Nuclear power plants are also thermally driven; however, the heating requirement for steam is not fossil-fuel reliant, but rather heated from the controlled splitting of uranium atoms in a process known as nuclear fission. As of January 2015, there were 99 operating commercial nuclear reactors at 61 nuclear power plants in the United States. The Fort Calhoun plant in Nebraska has one reactor with the smallest summer generating capacity of 502 megawatts (MW). The Palo Verde plant in Arizona has three reactors with the largest combined summer generating capacity of about 3,937 MW. For cost and technical reasons, nuclear power plants are generally used more intensively than coal or natural gas units. In 2014, 19 percent of national power output came from nuclear plants; however, national nuclear generation capacity was only 11 percent.

Figure 7: Overview of a Nuclear Power Generation Process



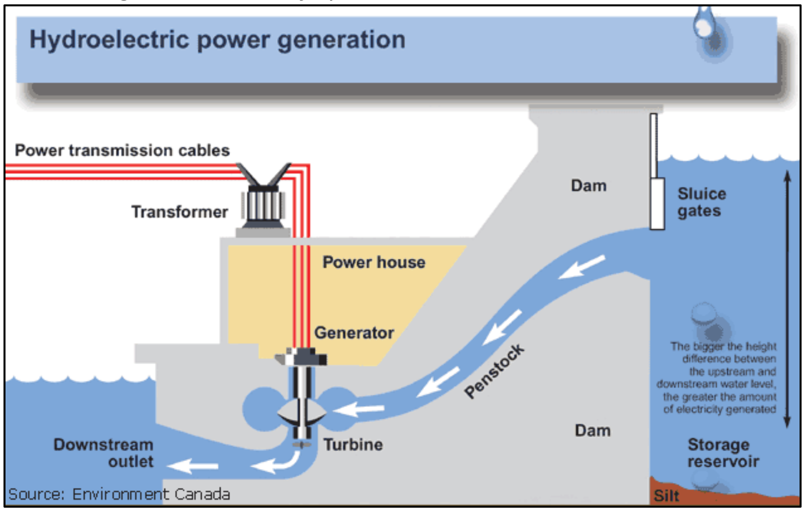
Sources: How Stuff Works / Progress Energy

Start up and shut down procedures for nuclear reactors are very lengthy as a result of the large magnitudes of energy involved in a nuclear reaction as well as the precautionary measures required when dealing with highly toxic sources of radiation. In an outage scenario, a nuclear power plant would either enter a "hot" or "cold" shutdown depending on the location of the problem. If the issue has impacted downstream units independent of the reactor (generator), the plant's reactor may remain online in a hot condition, which is more favorable for efficiently restarting the plant. Cold shutdowns are executed if a problem has been detected within the reactor or to replace depleted fuel rods.

Other Power Plants

Hydroelectric power plants transform potential energy in an elevated storage reservoir using gravity and fluid dynamics to drive turbine shafts. Hydro plants also supply pumped storage in which the facility consumes pumping power to recharge the reservoir during non-peak, low-price hours, so that a larger supply is available at peak hours and prices.

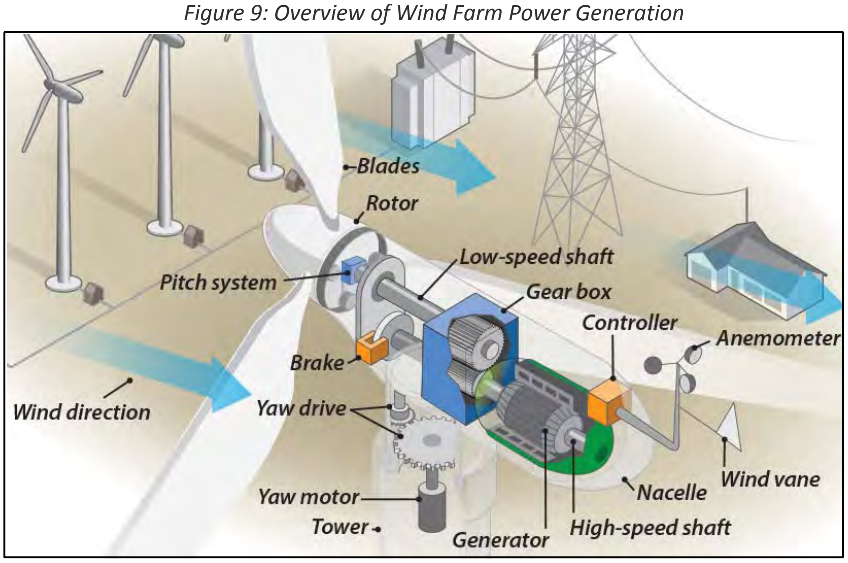
Figure 8: Overview of Hydroelectric Power Generation Process



Source: Environment Canada

Similarly, wind power utilizes natural wind currents to generate mechanical work. Solar photovoltaic technology[1] can convert radiation from the sun, as well as heat absorption into electrical current.

Figure 9: Overview of Wind Farm Power Generation



Source: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy

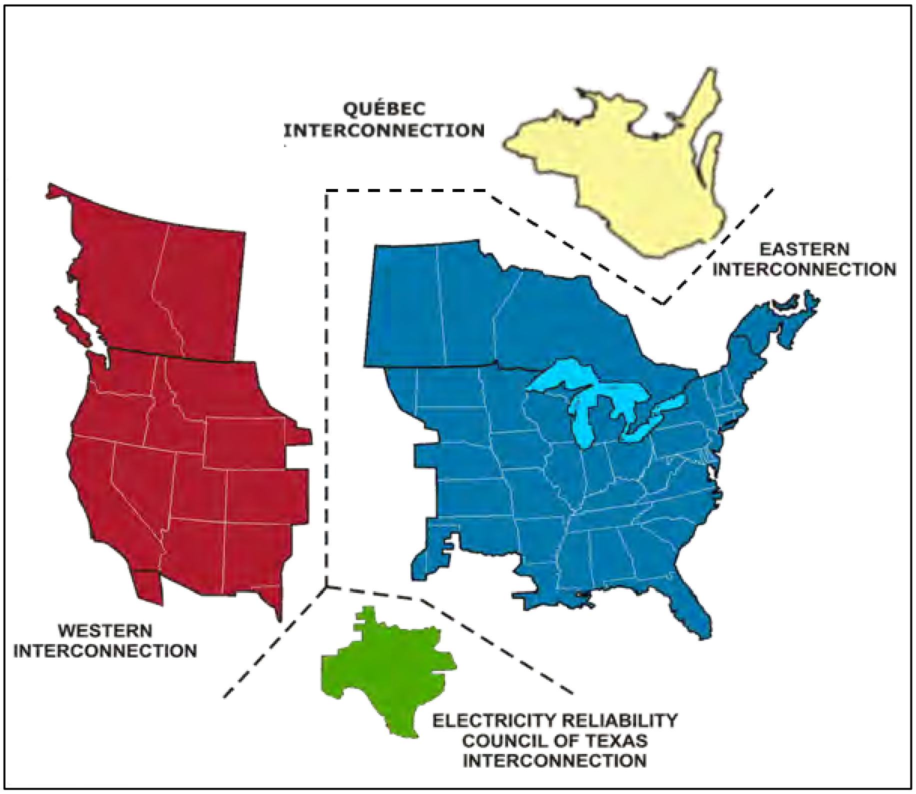
[1] Photovoltaic solar cells absorb light photons that positively ionize semiconductor materials to create free electric charges.

3.2 Transmission and the Grid

The Grid

The combined transmission and distribution network is known as the "power grid" or simply "the grid." North America's bulk power system actually comprises of four distinct power grids, also called interconnections. The Eastern Interconnection includes the eastern two-thirds of the continental United States and Canada from the Great Plains to the Eastern Seaboard. The Western Interconnection includes the western one-third of the continental United States, the Canadian provinces of Alberta and British Columbia, and a portion of Baja California Norte in Mexico. The Texas Interconnection comprises most of the State of Texas, and the Canadian province of Quebec is the fourth North American interconnection. The grid systems in Hawaii and Alaska are not connected to the grids in the lower 48 states.

Figure 10: Map of Four North American Power Grid Interconnections



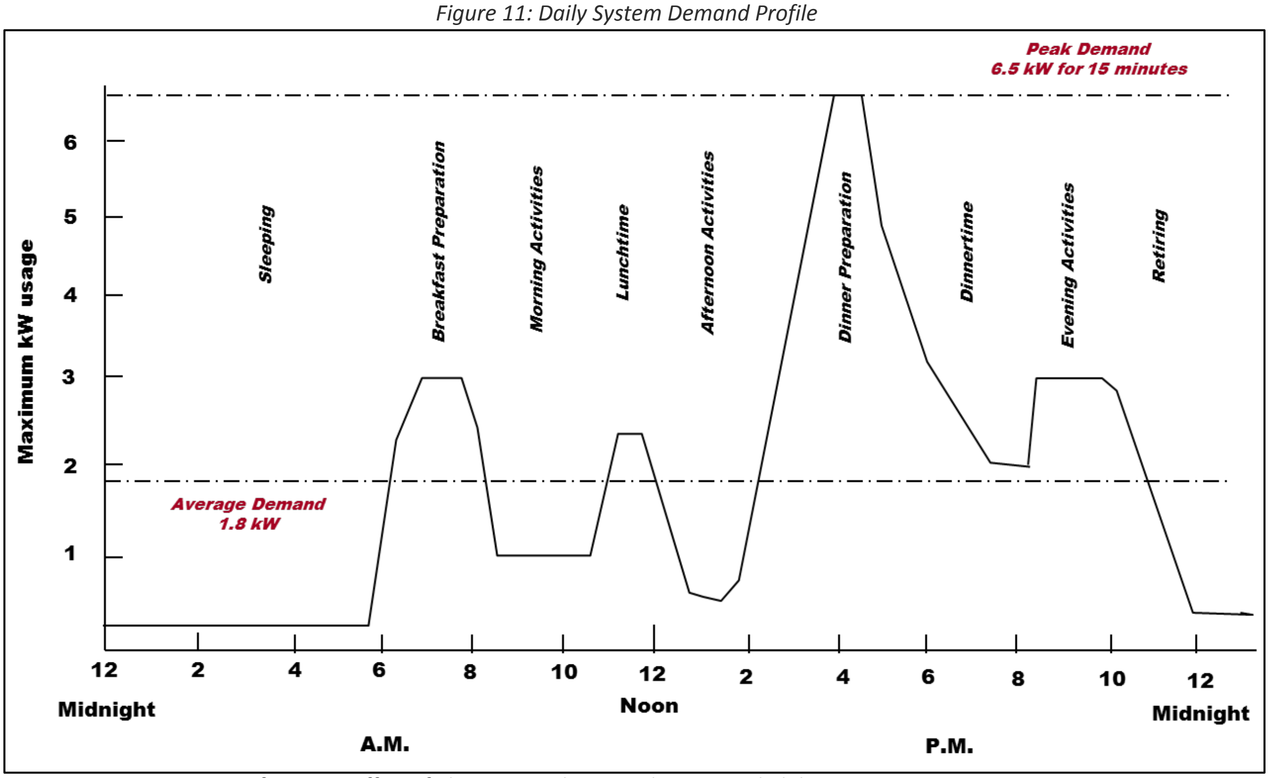
Source: North American Electric Reliability Corporation

Interconnections are zones in which utilities are electrically tied together during normal system conditions. Each interconnection operates independently of one another with the exception of a few direct current (DC) conversion links in between. Interconnections strive to operate at a synchronized average frequency of 60 Hertz, but can fall out of phase for a number of reasons. DC converter substations enable the synchronized transfer of power across interconnections regardless of the operating frequency as DC power is non-phase dependent. There are few converter substations in the United States.

Sending Power to the Grid

Power demand fluctuates throughout the day and across regions with varying population densities because utility-scale electricity storage does not exist. To keep the power grid balanced at all times, generation operators must dispatch enough power required to supply demand. Power dispatch is coordinated by the plant operator and a transmission system operator making communications critical at generation facilities. Figure 11 shows an example of a demand curve as it might occur over the course of a single day and is indicative to the level of human activity. Demand rises from off-peak hours in the early morning, approaching shoulder peaks during the work and school day. Priority peak occurs in the evening hours where peak load is reached. Because demand is hardly constant, generation must adjust accordingly. Base-loading power plants operate in off-peak hours to satisfy the minimum or base demands whereas peaking power plants gradually come online and provide power as demand approaches shoulder and peak loads. In order to rapidly accommodate fluctuating demand, natural gas-fired plants, which have faster start up times but typically higher fuel costs, are activated gradually for peaking demands. Coal and nuclear plants, which can take up to 12 or more hours to start, are most effective at satisfying base-load demands.

Figure 11: Daily System Demand Profile



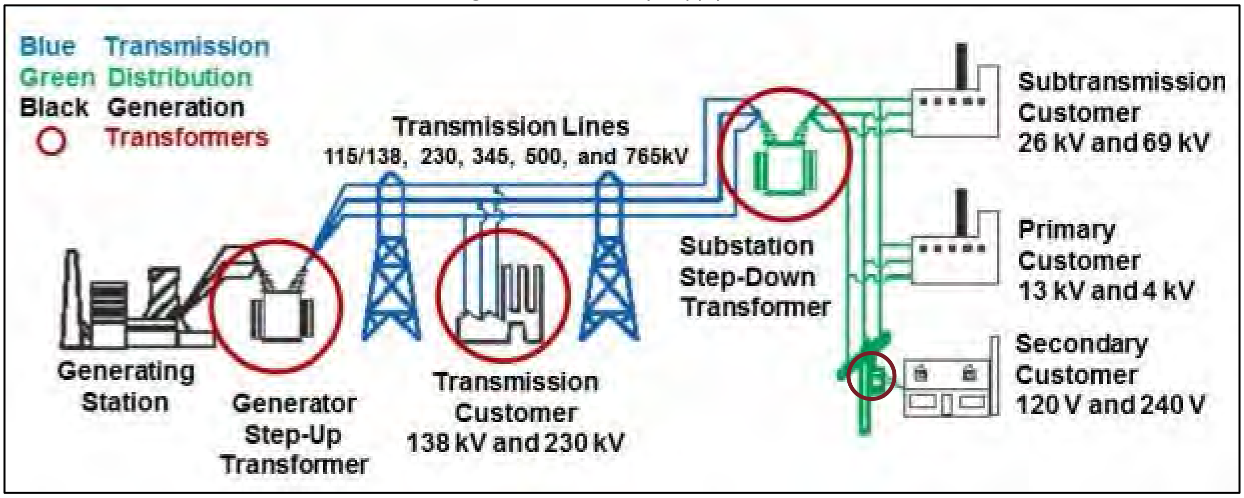
Source: U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability

Step-Up Transformers

Electricity is generally produced at 5 to 34.5 kilovolts (kV) and distributed at 15 to 34.5 kV, but transmitted at 69 to 765 kV. Because power plants are generally distant from demand centers, at constant power output, electricity cannot be transmitted over sizeable distances without meeting significant resistance and power loss; hence, a large driving force to efficiently transfer energy over long distances is required.

At a constant power rate, voltage and current are also proportional, meaning that an increase in voltage results from a reduction in current flow; thus, power plants utilize "step-up" transformers to drastically increase power generation voltage to the transmission system level. Transformers play several key roles in the supply chain, and are very technically complex. Facilities that house the equipment and conversion infrastructure are referred to as substations. The functionality and variations of substations and transformers will be addressed in more depth in subsequent sections.

Figure 12: Electricity Supply Chain



Source: U.S. Federal Energy Regulatory Commission and U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability

Transmission

Figure 13: High Voltage Transmission Towers

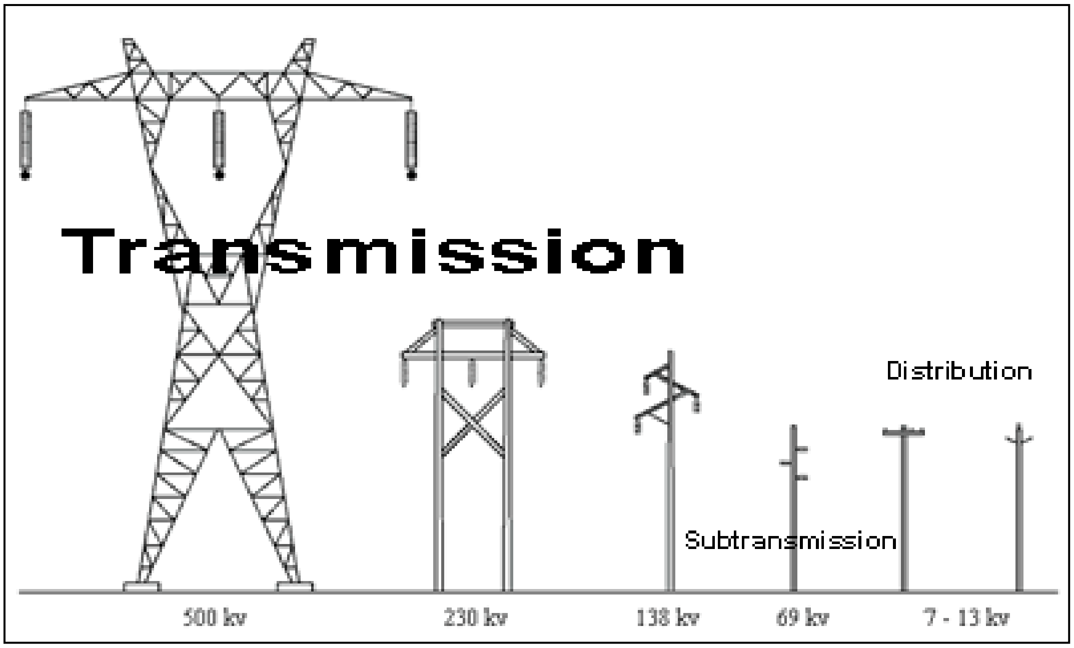
Source: U.S. Department of Energy

The United States' bulk electric system consists of more than 360,000 miles of transmission lines, including approximately 180,000 miles of high-voltage lines, connecting to about 7,000 power plants[2]. Power transmission lines facilitate the bulk transfer of electricity from a generating station to a local distribution network. These networks are designed to transport energy over long distances with minimal power losses which is made possible by boosting voltages at specific points along the electricity supply chain. The components of transmission lines consist of structural frames, conductor lines, cables, transformers, circuit breakers, switches, and substations. Transmission systems are generally administered on a regional basis by a regional transmission organization (RTO) or an independent system operator (ISO) which will be discussed in the Markets and Ownership Structures section.

[2] Source: North American Electric Reliability Corporation Electricity Supply & Demand Database, http://www.nerc.com/page.php?cid=4|38

Transmission lines that interconnect with each other to connect various regions and demand centers become transmission networks, and are distinct from local distribution lines. Typical transmission lines operate at 765, 500, 345, 230, and 138 kV; higher voltage classes require larger support structures and span lengths as shown in the following figure. Note how each structure has three line connections. A single-circuit transmission line consists of three conducting lines, one line for each phase in three-phase AC circuits.

Figure 14: Structural Variations of Transmission Towers



Source: U.S. Department of Labor, OSHA

Reactive Power in Transmission

Reactive power flow is required to stabilize electricity transfer from generating stations to load centers. The reactive power is the component of the apparent power that assists in maintaining voltage across transmission systems. Transmission voltage is stabilized by supplying the system with reactive power from generating stations and static capacitors built into transmission lines. Sources for reactive power must be located in close proximity to demand centers as flows are subject to significant resistance over transmission distance, and are consumed at load centers and on highly-utilized transmission lines. As transmission capacity utilization increases, more reactive power is consumed; thus, more is required to maintain system voltage. When the reactive power supply is limited, increased utilization will cause a voltage drop along the line. If reactive supply is not provided at the end of the line, the voltage could fall precipitously. At the point of voltage collapse, transmission systems can no longer transfer electric power from distant generation to energy users in load centers. Low-system voltage and reactive power flows were two contributing factors in the 2003 cascading Northeast blackout that affected 50 million people. For more information on reactive power, refer to Appendix B.

Substations

Substations not only provide crucial links for generation but also serve as key nodes for linking transmission and distribution networks to end-use customers. While a substation can provide a number of distinct system functions, most utilize transformers to adjust voltage along the supply chain. A substation may be designed initially for the purpose of bulk power transmission, but may also incorporate an additional transformer to distribute power locally at a lower voltage. Power lines are classified by their operational voltage levels, and transmission lines are designed to handle the higher voltage ranges in the following table. Transformer equipment at substations facilitate energy transfer over networks that operate at varying voltage levels.

Figure 15: Transmission Voltage Classes

Power Line Classification	Voltage Range [kV]	Purpose
Ultra High Voltage (UHV)	> 765	High Voltage Transmission > 765 kV
Extra High Voltage (EHV)	345, 500, 765	High Voltage Transmission
High Voltage (HV)	115, 138, 161, 230	
Medium Voltage (MV)	34, 46, 69	Subtransmission
Low Voltage (LV)	< 34	Distribution for residential or small commercial customers, and utilities

Source: U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability

A substation generally contains transformers, protective equipment (relays and circuit breakers), switches for controlling high-voltage connections, electronic instrumentation to monitor system performance and record data, and fire-fighting equipment in the event of an emergency. Some important functions that are carried out at substations are voltage control, monitoring the flow of electricity, monitoring reactive power flow, reactive power compensation, and improving power factors.

Listed below are frequently used terms for several types of substations in the bulk power system, along with a description and the function for each:

- **"Step-Up Substation":** Links a generation plant to the transmission system
  - Because AC power plants typically generate voltages below 35 kV, generator transformers provide the voltage "step-up" so that bulk power can be transmitted over long distances. Higher transmission voltage is analogous to increased pressure to deliver product through a pipeline. Generator substations are normally housed within the power plant, and act like a switch from the power plant to the grid.
- **"High Voltage Substation":** Connects high voltage transmission systems
  - Since high voltage transmission networks are highly redundant and facilitate power flow between systems of varying high-voltage levels, interconnecting transformers at transmission substations adjust voltages to network-specific levels.
- **"Step-Down Substation":** Connects a high-voltage transmission system to a sub-transmission system
  - For shorter power transmission distances from the main high-voltage transmission network, it can be economic to transmit on a subtransmission network at a voltage level in between standard transmission and distribution voltages. Larger substation transformers are more expensive to manufacture and operate.

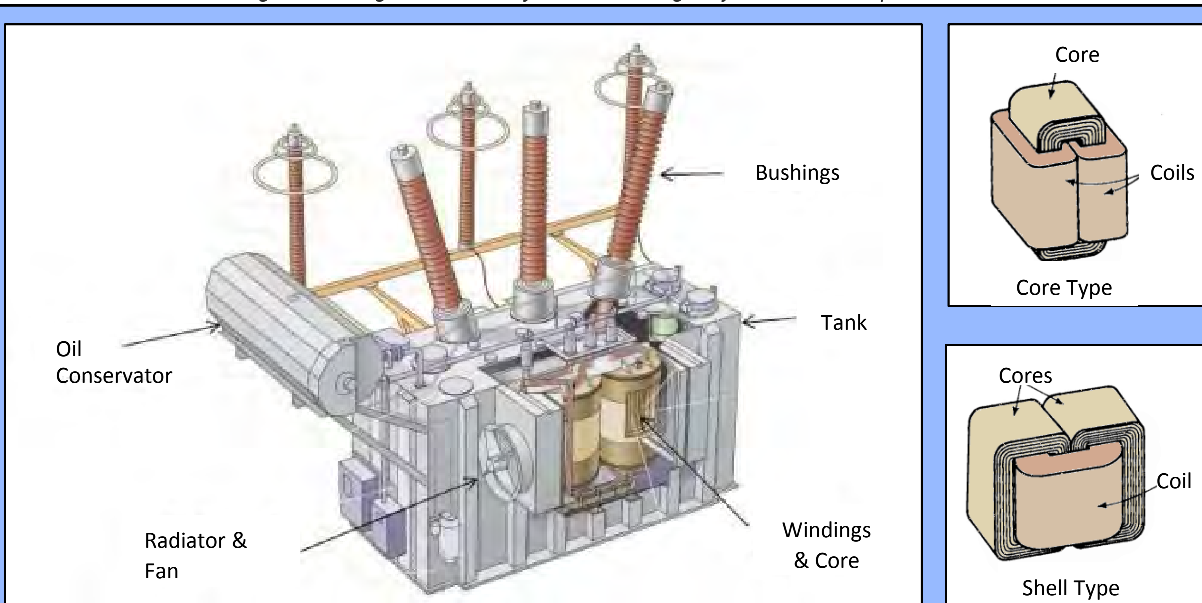
- **"Distribution Substation":** Connects transmission or subtransmission network to medium voltage distribution networks.
  - Once power has reached a load center, a "step-down" distribution substation reduces voltage to medium ranges for major distribution networks.
- **"Distribution Transformer":** Connects the medium voltage distribution system to end use customers
  - Because the voltage in major distribution lines is medium range, smaller, modular distribution transformers step voltage down to low utilization levels required by neighborhoods and commercial centers. Smaller distribution transformers are the cylindrical devices mounted on local distribution lines or mounted on a concrete pad in a neighborhood. Underground local distribution transformers are also common. These are typically not referred to as "substation" because they are modular and lack most of the equipment found in a large, high voltage substation.
- **"Converter Substation":** Connects non-synchronous AC transmission networks through high voltage direct current transmission (HVDC), or connects a HVDC transmission line to an AC transmission network.
  - High-voltage direct current substations are used to link AC power grids that are not operating at the same frequencies. The four major North American power grid interconnections, which will be discussed subsequently, are connected via HVDC transmission lines and substations. HVDC substations are also used to link HVDC transmission lines that are sometimes more economical than AC transmission over significantly long distances, or in the case of a submarine transmission system.
- **"Switching Substation":** Acts as a circuit breaker in transmission and distribution networks
  - These are the substations meant for switching purposes only and do not have transformer equipment. Switching substations are meant for disconnecting and connecting a part of the network and facilitating maintenance work.

Transformers

Transformers are critical equipment in delivering electricity to customers, but many are located in isolated areas and are vulnerable to weather events, acts of terrorism, and sabotage. The loss of transformers at substations represents a significant concern for energy security in the electricity supply chain due to shortages in inventory and manufacturing materials, increased global demand in grid-developing countries, and limited domestic manufacturing capabilities. Substations are highly specific to the systems they serve, which also limits the interchangeability of transformers. Replacing a transformer is associated with a long delivery lead time as they are generally difficult to transport due to their size and weight, and larger more sophisticated models are manufactured abroad. Failure of even a single unit could result in temporary service interruption.

Although power transformers come in a wide variety of sizes and configurations, they consist of two main components: the core; made of high-permeability, grain-oriented, silicon electrical steel, layered in pieces; and windings; made of copper conductors wound around the core, providing electrical input and output. Two basic configurations of core and windings exist, the core form and the shell form. In the usual shell-type power transformer, both primary and secondary windings are on one leg and are surrounded by the core; whereas, in a core-type power transformer, cylindrical windings cover the core legs. Shell form transformers typically use more electrical steel for the core and are more resilient to short-circuit in the transmission systems and are frequently used in industrial applications. The core and windings are contained in a rectangular, mechanical frame known as the tank. Other parts include bushings, which connect to transmission lines, as well as tap changers, power cable connectors, gas-operated relays, thermometers, relief devices, dehydrating breathers, oil level indicators, and other controls.

Figure 16: Large Power Transformer Detailing Major Internal Components



Component	Function
Core	Provides a path for magnetic flux.
Primary Winding	Receives electricity from the AC source.
Secondary Winding	Receives electricity from the primary winding and delivers it to the load.
Tank	Provides enclosure and protects internal components from dirt, moisture, and mechanical damage.
Radiator and Fan	Provides air flow and cooling system for internal equipment to regulate operational temperatures.
Oil Conservator	Provides sufficient storage for insulation oil which can increase in volume at high temperatures.
Bushings	Insulation device to allow safe connection of transmission wires into the tank enclosure of the transformer.

Sources: ABB and http://www.vias.org/matsch_capmag/img/matsch_caps_magnetics-787.png

Transformers and their components are unique due to their specificity in design and application, the availability of required materials and associated costs, and the timeline required for complete implementation. The startup of any large power transformer takes around 2 years and requires contract procurement, design, manufacturing, testing, delivery, and installation as illustrated in Figure 17. It is important to recognize that in the real world, delays in any of the steps could result in significant lengthening of the initial estimated lead time.

Figure 17: 2011 Large Power Transformer Procurement Process and Estimated Optimal Lead Time

Source: U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability

Pricewise, transformer labor costs and material prices vary by manufacturer, by market condition, and by location of the manufacturing facility. In 2010, the approximate cost of a large power transformer with a megavolt-ampere MVA[3] rating between 75 MVA and 500 MVA was estimated to range from $2 to $7.5 million in the United States; however, estimates were "Free on Board" factory costs, exclusive of transportation, installation, and other associated expenses, which generally add 25 to 30 percent to the total cost. Figure 18 shows characteristics and estimated costs for larger power transformers based upon 2011 data.

Figure 18: Estimated Characteristics of Large Power Transformers in 2011

Voltage Rating (Primary-Secondary)	Capability MVA Rating	Approximate Price ($)	Approximate Weight & Dimensions
Transmission Transformer			
Three Phase			
230–115kV	300	$2,000,000	170 tons (340,000 lb) 21ft W–27ft L–25ft H
345–138kV	500	$4,000,000	335 tons (670,000 lb) 45ft W–25ft L–30ft H
765–138kV	750	$7,500,000	410 tons (820,000 lb) 56ft W–40ft L–45ft H
Single Phase			
765–345kV	500	$4,500,000	235 tons (470,000 lb) 40ft W–30ft L–40ft H
Generator Step-Up Transformer			
Three Phase			
115–13.8kV	75	$1,000,000	110 tons (220,000 lb) 16ft W–25ft L–20ft H
345—13.8kV	300	$2,500,000	185 tons (370,000 lb) 21ft W–40ft L–27ft H
Single Phase			
345–22kV	300	$3,000,000	225 tons (450,000 lb) 35ft W–20ft L–30ft H
765–26kV	500	$5,000,000	325 tons (650,000 lb) 33ft W–25ft L–40ft H

Source: U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability

[3] MVA, or megavolt-ampere represent the power rating, or range required to support voltage ratings of various transformers.

Fact Box

Substation Transformers

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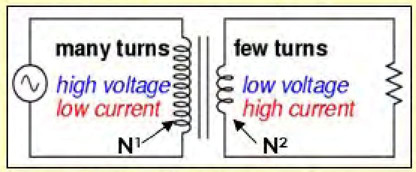
- Transformers harness electromagnetic properties of electrical energy to convert voltage levels in the transmission system, enabling safe, efficient delivery of electricity
- Consists of two conductive coils arranged so that the magnetic field of one coil influences the other
- Voltage conversion factor known as the "turns" ratio: the number of turns in the primary coil (N^1) to the number of turns in the secondary coil (N^2)

Step Down Circuit Diagram



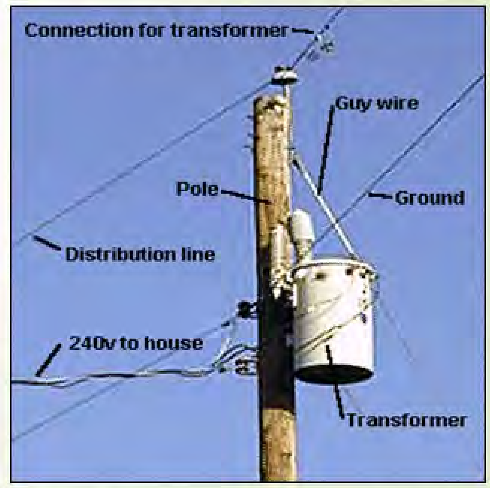
Turns Ratio: $N^1 > N^2$ for a Step-Down Transformer. Voltage reduction proportional to the factor of N^2/N^1 .

Transformer materials consist of iron-steel cores, conductive metal windings, and metal encasement; very heavy and very expensive

Supply Chain Vulnerabilities

- Many substations are located in isolated areas and are vulnerable to damage
- Limited interchangeability due to differing specifications
- Long delivery lead times; large models are difficult to transport
- Some only manufactured abroad.

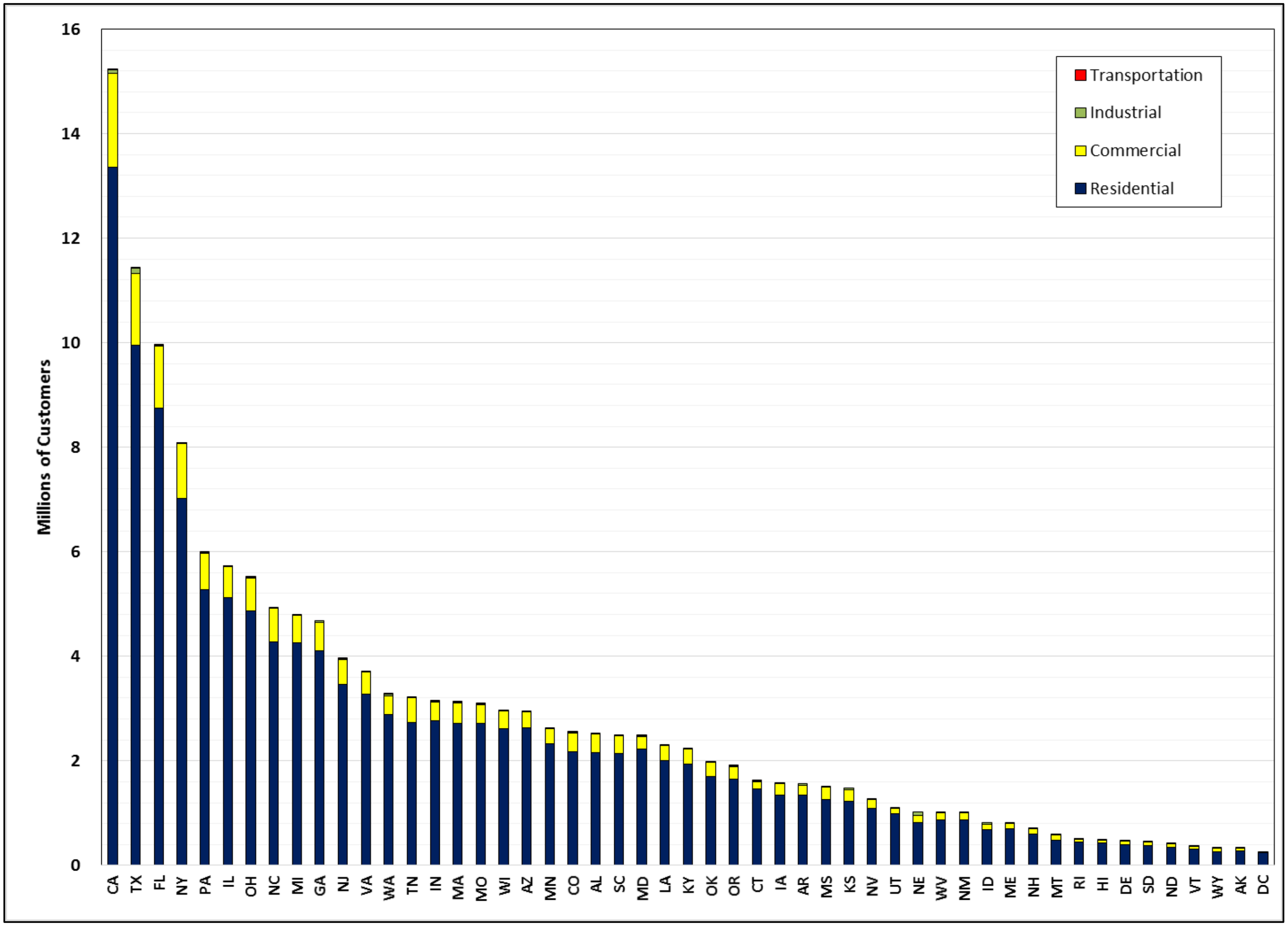
Step Up Transformer at a Generation Substation, $N^2 > N^1$



(Above) This distribution transformer's job is to reduce the 4,160 distribution voltage down to the 240 utilization voltage normal for household electrical service.

Sources: U.S. Department of Labor, OSHA; http://www.miningmayhem.com/2009/05/transformer-into-river.html; and http://www.ibiblio.org/kuphaldt/electricCircuits/AC/AC_9.html

Figure 19: State-Level Distribution of Electric Customers in 2013

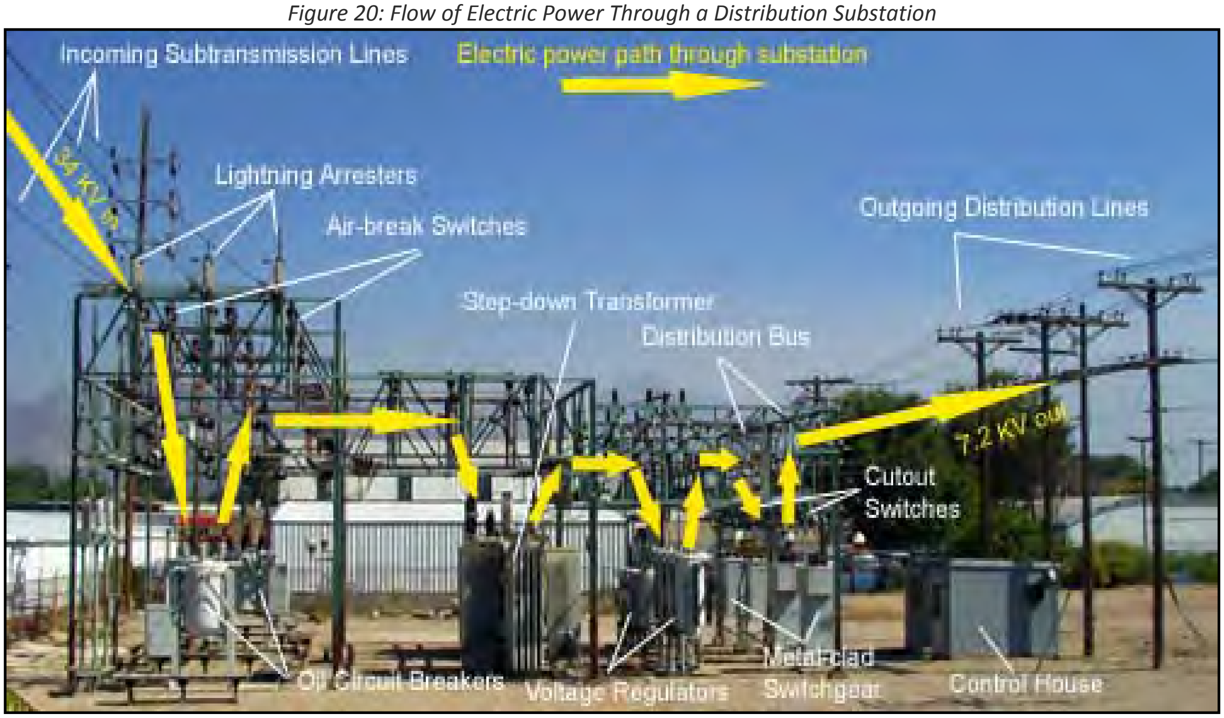


Source: U.S. Energy Information Administration, EIA

3.3 Distribution

The power distribution system is the final stage in the delivery of electric power, carrying electricity out of the transmission system to individual customers. Distribution systems can link directly into high-voltage transmission networks, or be fed by subtransmission networks. Distribution substations reduce high voltages to medium-range voltages and route low voltages over distribution power lines to commercial and residential customers.

Figure 20: Flow of Electric Power Through a Distribution Substation



Source: U.S. Department of Labor, OSHA

The figure above illustrates the flow of electricity through a distribution substation. The incoming 34 kV subtransmission lines first pass through a series of protective equipment before entering the transformer. Lightning arresters are designed to attract power surges from lightning strikes safely to ground, away from the voltage reduction equipment. Switches, circuit breakers, and voltage regulators assist in controlling and routing high voltage connections through the transformer to the distribution bus where the outgoing distribution lines connect to the substation. Although not shown above, substations can have multiple transformers and distribution buses to route power through multiple low-voltage networks. The substation above reduces transmission voltage from 34 kV to the 7.2 kV distribution level. Primary distribution circuits, also known as express feeders or distribution main feeders, carry medium-range voltage to additional distribution transformers that are located in closer proximity to load areas. Distribution transformers are the cylindrical devices mounted on local power lines or on a concrete pad in a neighborhood. Underground local distribution transformers are also common. Distribution transformers further reduce the voltage to utilization levels and feed power to secondary circuits where residential and commercial customers receive power off a service drop through a metering socket.

Figure 21: Diagram of Transmission and Distribution Networks

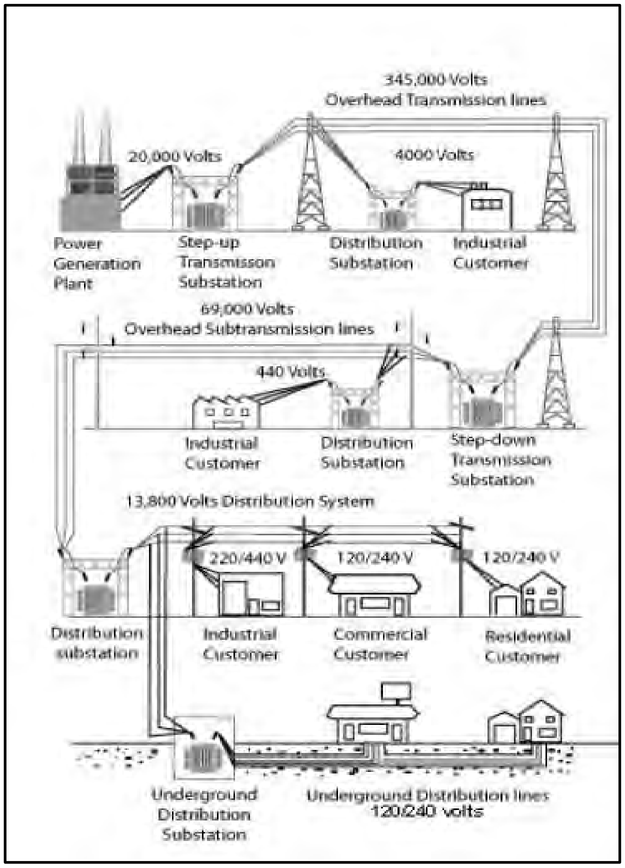
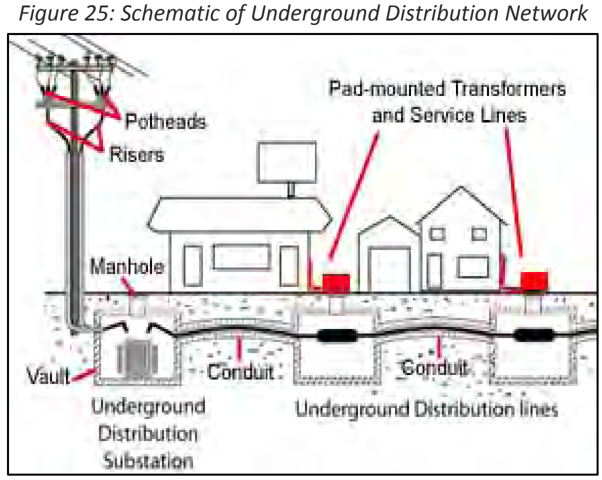


Figure 22: Service Drop for an Industrial Facility

Figure 23: Household Service Line Drop from Distribution Line

Figure 24: Pad-Mounted Distribution Transformer

Figure 25: Schematic of Underground Distribution Network

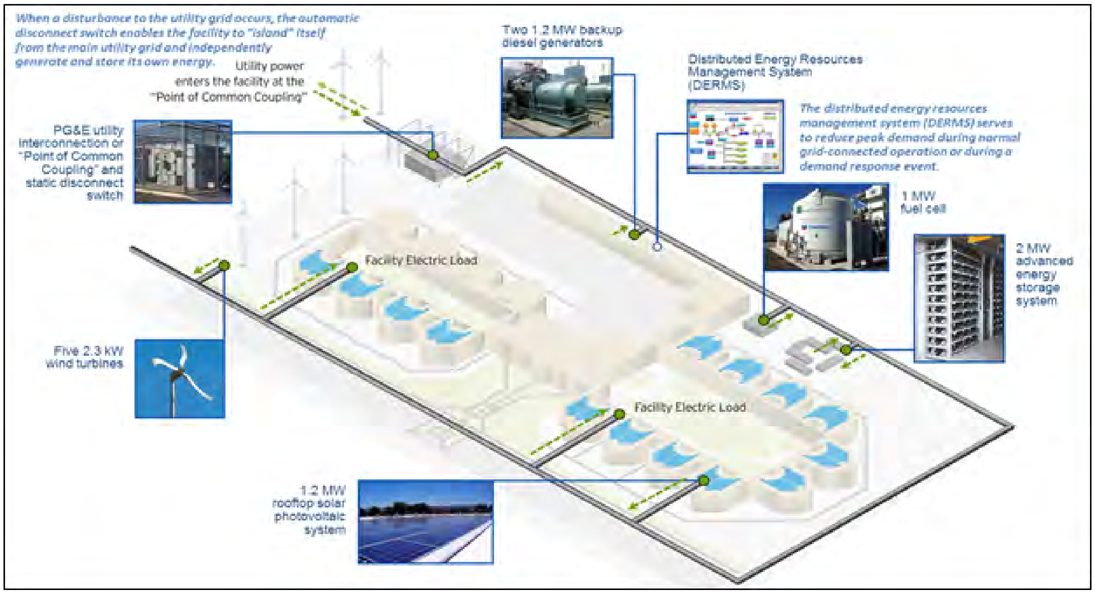


Sources for Above Figures: U.S. Department of Labor, OSHA

Distributed Energy Resources

Unlike power generation plants that require an interconnection to the transmission network, distributed energy resources position modular generation capacity downstream from the transmission network, allowing generation flexibility and supplemental power supplies located closer to load centers. A group of localized distributed generation is known as a microgrid and can function independently of the power grid in the event of an outage.

Figure 26: Commercial Microgrid Application at Santa Rita Jail in California



Source: County of Alameda, California; http://www.acgov.org/pdf/SRJMicrogrid.pdf

The commercial microgrid demonstration project shown in Figure 26 illustrates a viable approach to utilize and integrate renewable and clean distributed energy resources to accommodate local loads. The objectives of this project were to reduce the peak load of utility-supplied power and to provide energy surety to 100 percent of the jail's load. The entire 12 kV distribution system downstream from Pacific Gas and Electric Company's (PG&E) interconnection will be kept energized in the event of a utility outage. In the event of a microgrid failure, the existing emergency backup generation system will be used to provide the second layer of outage protection, in conjunction with the established load shedding criteria.

4 MARKETS AND OWNERSHIP STRUCTURES

4.1 OVERVIEW

Before discussing various markets within the U.S. electricity sector, it is important to define some of the major players and regions that make up the industry. The first few sections that follow will provide an overview of major regulatory bodies, regional organizations, and utilities and their ownership structures. Later in this section, the various markets within the electric industry will be described.

4.2 FERC

The Federal Energy Regulatory Commission (FERC) is an independent agency within the U.S. Department of Energy that regulates the interstate transmission of electricity (as well as natural gas and oil) within the United States. FERC also regulates natural gas and hydropower projects. Within the electricity sector, FERC:

- Regulates the transmission and wholesale sales of electricity in interstate commerce.
- Reviews certain mergers and acquisitions and corporate transactions by electricity companies.
- Reviews the siting application for electric transmission projects under limited circumstance.
- Licenses and inspects private, municipal, and State hydroelectric projects.
- Protects the reliability of the high voltage interstate transmission system through mandatory reliability standards.
- Monitors and investigates energy markets.
- Enforces FERC regulatory requirements through imposition of civil penalties and other means.
- Oversees environmental matters related to hydroelectricity projects.
- Administers accounting and financial reporting regulations and conduct of regulated companies.

The Energy Policy Act of 2005 expanded FERC's authority to enforce regulations concerning the reliable availability of energy resources. FERC is entrusted with assisting consumers in obtaining reliable, efficient, and sustainable energy services at a reasonable cost through appropriate regulatory and market means by: (1) ensuring that rates, terms and conditions are just, reasonable and not unduly discriminatory or preferential; (2) promoting the development of safe, reliable and efficient energy infrastructure that serves the public interest; and (3) achieving organizational excellence by utilizing resources effectively, adequately equipping FERC employees for success, and executing responsive and transparent processes that strengthen public trust.

To maintain FERC’s independence as a regulatory agency capable of providing fair and unbiased decisions, neither the President of the United States nor Congress reviews the decisions of FERC. FERC decisions are only reviewable by the Federal courts.

It is important to note that FERC does not regulate retail electricity sales to retail customers, approve the construction of electric generation assets, regulate the activities of nuclear power plants, assess reliability problems related to distribution facilities, or monitor utility vegetation control residential areas.

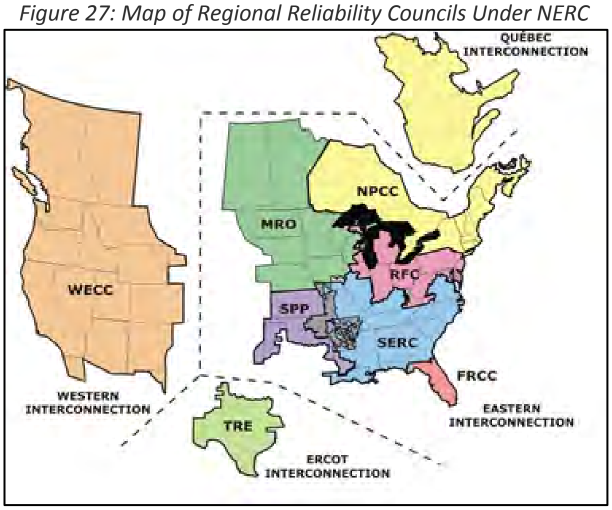
4.3 NERC

The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority whose objective is to ensure the reliability of the bulk power system in North America. In 2006, FERC designated NERC as the government's electrical reliability organization (ERO), thereby granting NERC the power to oversee and regulate the electrical market according to certain reliability standards. Although NERC is the organization that audits power companies and levies fines for non-compliance, the authority behind NERC's decisions comes from FERC. Several of NERC's responsibilities include:

- Developing and enforcing reliability standards
- Annually assessing seasonal and long-term reliability
- Monitoring the bulk power system through system awareness
- Educating, training, and certifying industry personnel.

NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico made up of regional reliability coordinators. NERC has jurisdiction over electric users, owners, and operators of the bulk power system. In the United States, FERC oversees the operations of NERC as an ERO.

Figure 27: Map of Regional Reliability Councils Under NERC



Source: NERC

4.4 ISOs/RTOs

Within the three main interconnections in the United States lie regional entities called regional transmission organizations (RTOs) and independent system operators (ISOs). The formation of ISOs and RTOs comes at the direction or recommendation of the Federal Energy Regulatory Commission (FERC). The role of ISOs and RTOs are similar and may be confusing. Comparable to an RTO, ISOs either do not meet the minimum requirements specified by FERC to hold the designation of RTO or have not petitioned FERC for that status. In short, an ISO operates the region's electricity grid, administers the region's wholesale electricity markets, and provides reliability planning for the region's bulk electricity system. RTO's perform the same functions as the ISOs, but have greater responsibility for the

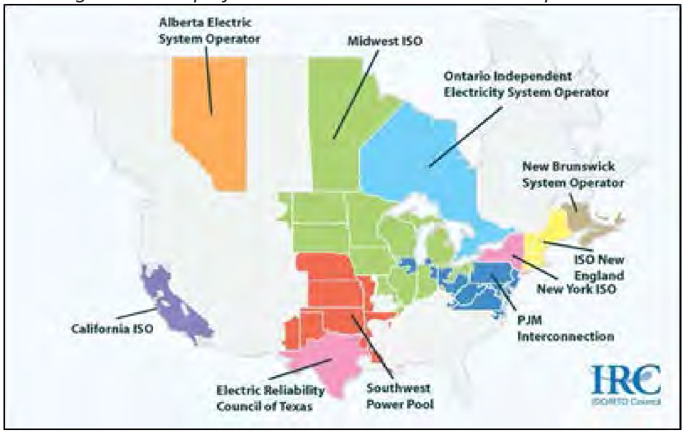
transmission network as established by the FERC. The RTOs coordinate, control, and monitor the operation of the electric power system within their territory. They also monitor the operation of the region's transmission network by providing fair transmission access. ISOs/RTOs engage in regional planning to make sure the needs of the system are met with the appropriate infrastructure. Before ISOs/RTOs were developed, individual utilities were responsible for coordinating and developing transmission plans. Utilities in areas where there is no RTO or ISO continue to serve this function. As can be seen from the map below, there are large sections of the United States, particularly in the Southeast and the West, where there is no ISO or RTO. Electric utilities in these areas, however, are still subject to the same rules under FERC. The Electric Reliability Council of Texas (ERCOT) does not fall under interstate FERC authorities over interstate transmission and wholesale markets, but is still subject to NERC oversight and FERC regulation for reliability.
There are currently seven ISOs within North America[4]:

- CAISO—California ISO
- NYISO—New York ISO
- ERCOT—Electric Reliability Council of Texas; also a Regional Reliability Council
- MISO—Midcontinent Independent System Operator
- ISO-NE—ISO New England
- AESO—Alberta Electric System Operator
- IESO—Independent Electricity System Operator

There are currently 4 RTOs within North America[5]:

- PJM—PJM Interconnection
- MISO—Midcontinent Independent System Operator; also an RTO
- SPP—Southwest Power Pool; also a Regional Reliability Council
- ISONE—ISO New England; also an RTO

Figure 28: Map of North American Transmission Operators



Source: IRC ISO/RTO Council

4 http://www.ferc.gov/industries/electric/indus-act/rto.asp
5 http://www.ferc.gov/industries/electric/indus-act/rto.asp

4.5 State Regulatory Agencies

The role of State regulatory bodies in the electricity sector can vary significantly by State. There are numerous State agencies that regulate the electric industry. The list below describes the function of each as they are related to electricity.

1. **State Public Service Commission:** Names of these entities can vary by State, such as Public Utilities Commission or Corporation Commission. State commissions regulate what are fair and reasonable rates for electric service under their jurisdiction. Commissions adopt and enforce regulations that protect the public's safety and interests, study the economic and environmental impact of utility operations, ensure the safe and reliable service of electricity to customers, and in some cases, mediate disputes between the utility and its customers. Commissions are also charged with electric system reliability. They oversee utility plans for vegetation management, facility inspections, and maintenance of assets.
2. **State Department of Environmental Protection:** Names of these entities can also vary by State. Some States have a Department of Environmental Quality, which serves a similar purpose. The basic role of these organizations is to regulate the State's air, land, and water resources. These departments provide air permits for the construction of pollutant emitting assets, ensure public safety by cleaning contaminated sites, and monitor emissions by companies.

4.6 Utilities

A utility is a power company that generates, transmits, and distributes electricity for sale to customers. Not all utilities, however, must provide all three functions. There are more than 3,200 electric utilities in the United States, serving over 145 million customers.[6] The following section describes the various types of electric utilities in the Nation:

- **Investor-Owned Utilities (IOUs)** are for-profit companies owned by their shareholders. These utilities may have service territories in one or more States. State commissions will grant IOUs the license to operate in specific areas of the State under certain terms and conditions. Their interstate generation, transmission, and power sales are regulated by FERC and their distribution system and retail sales are regulated by State commissions.
- **Public Power Utilities (also known as "Municipals" or "Munis")** are not-for-profit utilities owned by cities and counties. City-owned utilities are referred to as municipal utilities (munis). Universities and military bases can own and operate their own utilities. These are generally not regulated by FERC or by States, but by their own local government.
- **Cooperatives (Co-Ops)** are not-for-profit entities owned by their members. They must have democratic governance and operate at cost. Members vote for representatives to the co-op's Board of Directors who oversee operations. Any revenue in excess of costs must be returned to members. Co-ops also tend to serve in rural areas that were not historically served by other utilities.

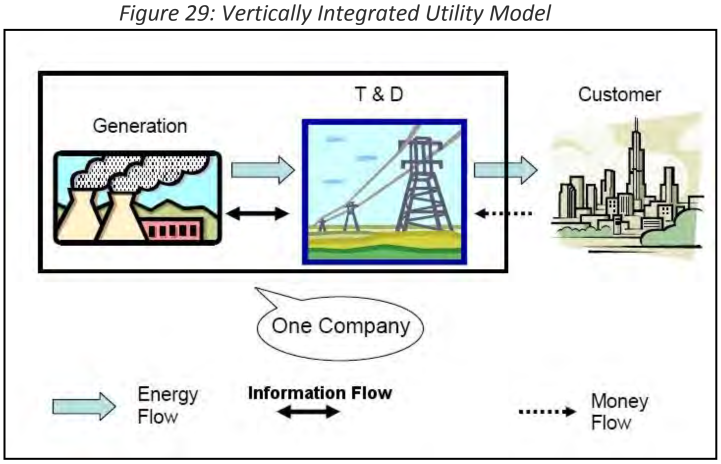
[6] Energy Information Administration Forms EIA-861

- **Federal Power Programs** include the Bonneville Power Administration (BPA), the Tennessee Valley Authority (TVA), the Southeastern Power Administration (SWPA), the Southeastern Power Administration (SEPA), and the Western Area Power Administration (WAPA). These wholesale-only entities provide a range of electric service functions to other utilities (mostly to munis) for distribution to end users. TVA is an independent, Government-owned corporation, but should not be confused with BPA and WAPA, also known as Power Marketing Administrations (PMAs). BPA and TVA own both generation and transmission facilities. WAPA is a transmission-only utility providing power from Federal hydroelectric facilities in the West to other retail utilities. PMAs are explained in more detail in the fact box on the next page.
- **Independent Power Producers**, or sometimes called a non-utility generator, are privately-owned businesses that own and operate their own generation assets and sell power to other utilities or directly to end users.

Vertically Integrated Utility Model

The sale and delivery of electricity can occur in two ways: the traditional, regulated, vertically integrated model and a more competitive approach that uses electricity as a tradable commodity. In a vertically integrated model, utilities are responsible for generation, transmission, and distribution of electricity in a specific geographical area. They may own all or have shares in power plants and transmission lines, or purchase power through contracts with other electricity producers. The price the customer pays in a vertical model is based on costs to serve over a period of time. These costs are monitored by State regulatory commissions and are adjusted in rate cases. The following diagram provides an overview of how a vertically integrated model is structured.

Figure 29: Vertically Integrated Utility Model



Source: National Programme on Technology Enhanced Learning

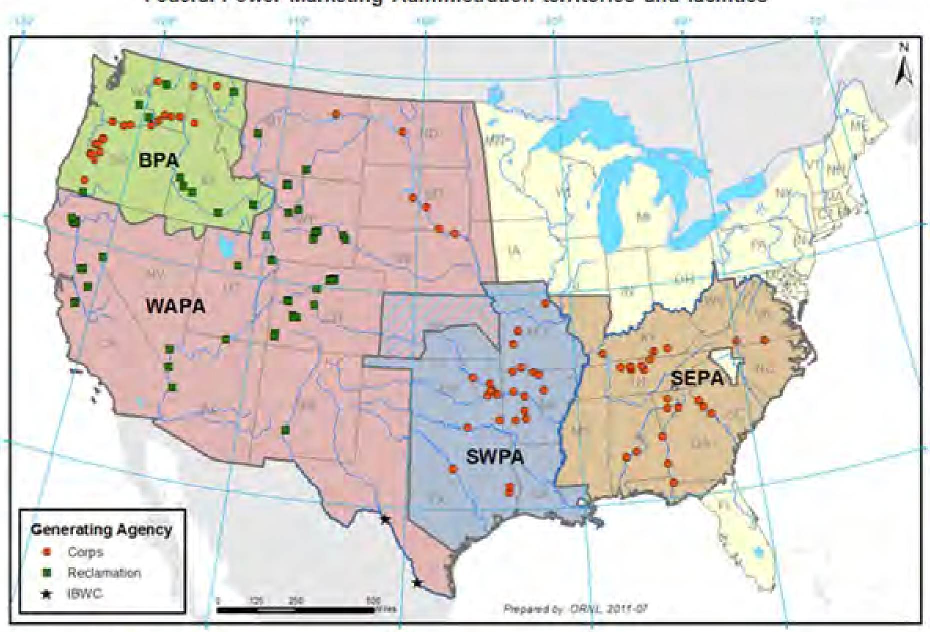
4.7 Wholesale Electricity Markets

Electricity can also be bought and sold in what is known as a wholesale market. The wholesale electricity market is where producers of electricity offer their electricity output to load serving entities (LSEs) and power marketers who sell to LSEs and other marketers. With the exception of ERCOT, sales of wholesale power are regulated by FERC. ISOs and RTOs administer wholesale power markets. They dispatch the system in accordance with their respective market rules employing some form of economic dispatch algorithm, and can provide market monitoring oversite. Both ISOs and RTOs provide open access to transmission and to ancillary services such as reserves and voltage support.

Fact Box: Power Market Administrations

U.S. Department of Energy
Office of Electricity Delivery
and Energy Reliability

- Four federal Power Marketing Administrations (PMAs) operate electric systems and sell the electrical output of federally owned and operated hydroelectric dams in 33 states. The Bonneville Power Administration (BPA), the Western Area Power Administration (WAPA), the Southeastern Power Administration (SEPA), and the Southwestern Power Administration (SWPA) marketed 42% of the nation's hydroelectricity in 2012, representing 7% of total generation in the United States. There is minor overlap in territories, but generally, the territories are self-contained. The U.S. Army Corp of Engineers and the Department of Interior's Bureau of Reclamation also own and operate hydroelectric facilities within these regions.
- The purpose of a PMA is to market wholesale power. In most cases, PMAs do not own their own electric generation plants. They market the electricity that is generated by plants and acts as a balancing authority (ensures electricity supply matches electricity demand at all times).
- PMAs also have a role in the transmission system as both transmission owners and operators, however SEPA does not own any transmission assets.



Source: EIA

BPA – Owns and operates three-quarters of the high voltage transmission system in its territory. BPA also owns the Columbia Nuclear Generating Station in Washington.

WAPA – Service area composed of a 15-state region with more than 17,000 circuit miles of transmission systems that carry electricity from 56 hydropower plants operated by the Bureau of Reclamation, U.S. Army Corps of Engineers and the International Boundary and Water Commission. WAPA also markets power from the Hoover Dam, the nation's sixth largest hydroelectric plant in the U.S. located on the Colorado River.

SWPA – Markets hydroelectric power from 24 U.S. Army Corps of Engineers dams.

SEPA - Markets hydroelectric power from 23 U.S. Army Corps of Engineers water projects.

4.8 Retail Electricity Markets

The retail market involves the sale of electricity from an electricity provider to an end-user. The end-user could be a large industrial facility, small business, or individual household. In every State, regardless of whether there is retail competition or not, the electricity supply for end-users is obtained either through the competitive wholesale market, or from utility-owned rate-based generation, or a combination of the two. All States regulate rates for the delivery of electricity to end users (customers) through distribution wires and related systems. In States where there is full retail competition, "retail choice", customers may choose between their current utility supplier and other competitive suppliers for the generation portion of their electric service. Competitive retail suppliers provide a variety of service plans that give consumers and businesses options for electricity purchases. The price the end-user pays, or the retail price, may not reflect the real-time pricing of wholesale market pricing. Retail prices may be an average of annual costs or some other mechanism to determine end-user prices.

For investor-owned utilities, the regulation of retail markets falls under the jurisdiction of states. State regulatory commissions, which are often called the State "Public Utility Commission" or "Public Service Commission," regulate a utility's costs and rate of return. Municipally- and cooperatively-owned utilities may be subject to some State regulation but in general, self-regulate their costs. As non-profit entities, municipally- and cooperatively-owned do not earn a return on capital invested. In retail choice States, the commissions can require competitive suppliers to be licensed and subject to some regulation before they are allowed to service customers. In States without retail competition, commissions regulate the expenditures of investor-owned utilities and set an authorized rate of return on capital invested. In these States, where utilities are vertically integrated, utilities may construct, own and operate power plants and the costs are reflected in retail prices.

4.9 Capacity Markets

To meet Federal and State reliability requirements, grid operators must ensure that load serving entities have enough resources to meet expected demand plus a "reserve margin," that provides for a cushion during unexpected spikes in demand or potential loss of a supply or transmission resource. Reserve margins help operators maintain the reliability of the system. Capacity markets in RTO/ISO regions are typically set up to ensure that there are sufficient resources available to serve load plus reserves at some point in the future, typically from one month to several years out in time. Capacity markets may use auctions to lock in prices for electric capacity from generation resources well before they are actually needed (3 years in some markets). Capacity markets can also be marketplaces for demand response in which customers reduce their demand when called upon to do so in exchange for capacity payments similar to what generators receive. Prices vary by location and timing of capacity commitments and typically not by size or fuel type. ISO New England, PJM, MISO and NYISO operate capacity markets, while other ISOs do not currently have capacity markets.

5 Power Outages and Restoration

When disaster strikes, utilities mobilize crews to restore power to their customers as quickly as possible. The process begins well before storms are even on the radar. Utilities are prepared for all kinds of storms and situations, which requires planning for standard operating procedures and procuring resources to meet a wide variety of challenges. The following sections discuss the vulnerabilities of the power sector, preparation for events, and restoration efforts.

5.1 Power Sector Vulnerabilities

The power sector is vulnerable to various disruptive events that require preparation for mitigating impacts and restoring service in a timely fashion. The following is a list of risks that the sector is susceptible to:

1. **Weather-Related:** Outages due to weather events such as hurricanes, tropical storms, tornadoes, snow and ice storms, and flooding. Outages due to weather are the most common type of disruptive events.
2. **Cyberterrorism:** Hackers from around the world can attack areas within the U.S. power grid, shutting off power to millions. While there have been no known cases of cyberterrorism affecting the U.S. grid and causing power outages, utilities and agencies across the country are well aware of the potential risks associated with cyberterrorism.
3. **Theft and Physical attacks:** Electric assets are sometimes targets of theft and physical attacks by individuals or groups. Recently, a California substation was attacked, resulting in the shutdown of numerous giant transformers that supplied power to an extensive commercial and industrial customer base.
4. **Man-Made Accidents:** Vehicle crashes, software-related glitches, and other human errors can also result in power outages. Examples include, civilian vehicles crashing into utility poles or utility employees accidentally tripping wires while conducting routine maintenance.
5. **Supply/Demand:** A supply and demand imbalance within a given area can produce power failures. This could result from a sudden surge in demand due to extreme temperatures or unplanned power plant outages. In April 2006, parts of Middle and South Texas faced rolling blackouts due to high excess demand from high temperatures. In February 2011, 50 power plants tripped offline, causing rolling blackouts in North and Central Texas.
6. **Other Natural Events:** Wildfires, earthquakes, and animals can interfere with electrical equipment. In August 2014, an earthquake in Napa County, California left more than 70,000 customers without power.

The 2003 Northeast blackout is an example of a complex large-scale outage event that was caused by multiple factors. The Fact Box on the next page provides details and a timeline of events leading up to the historic blackout that left 50 million people without power in the Northeastern United States and Canada.

Fact Box

2003 Northeast Blackout

U.S. Department of Energy
Office of Electricity Delivery
and Energy Reliability

- The most devastating blackout to hit the U.S. power industrial complex occurred on August 14, 2003, leaving close to 50 million people across the Great Lakes Region without power, some for up to two weeks
- A number of system factors primed the region for a cascading failure: deferred vegetation management, faulty alarm equipment, inexperienced operators, and lack of communication and situational awareness amongst supply chain operators
- Loss of generation across the region imposed heavy congestion and reactive power demands on the Ohio transmission system. The line-tripping domino effect placed increased stress on northwest generation in Michigan, further disconnecting the region from the rest of the grid. With lack of western generation support, the current reversed spreading outages northeast through Pennsylvania, and into New York and Ontario

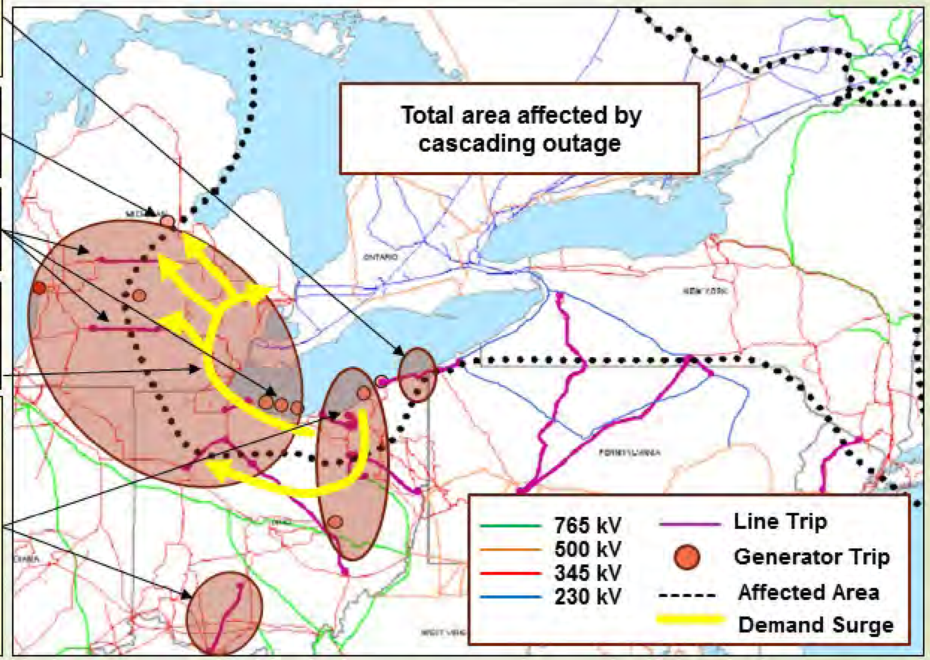
4:10:38 PM – Surge that had been flowing northwest suddenly reverses flow, tripping the Ohio-Pennsylvania line and sending the cascade across Pennsylvania, New York, and Ontario

4:10:37 PM – Significant generation trip imposes depressed system voltages across Michigan

4:10:04 PM – 20 generation units trip along Lake Eerie, surging power flows and tripping Michigan's East-West 345kV lines.

4:09 PM – Cleveland-Akron surge triggers collapse of 345 kV Ohio system; Northern Ohio and Detroit loads forced power demands north on Eastern Michigan.

12:05 – 4:06PM – Unplanned generator trips, alarm notification failures, and miscommunication between plant and system operators leads to voltage and reactive power abnormalities ultimately causing low system voltage and significant line sagging. Three 345kV lines trip from vegetation contact triggering high electricity flows over lower level 138kV lines and 600 MW of sudden load shedding in the Cleveland-Akron area.



Sources: U.S./Canada Power Outage Task Force, August 2013 Outage Sequence of Events: Initial Blackout Timeline, September 12, 2003.
U.S./Canada Power Outage Task Force, Final Report on the August 2013, 2003 Blackout: Causes and Recommendations, April 2004.

5.2 Black Start

The 2003 blackout was so widespread and severe that black start procedures were required to bootstrap the affected electric grid. A "black start" is the process of restoring a power unit(s) to operation without relying on external electric power from the transmission network. Typically, a plant coming online requires electricity for startup units and control equipment. When the entire grid is down, plants have no external sources of power to restart, and thus rely on dedicated black start diesel generators.

Different types of plants can perform black start functions; nuclear and hydro units are typically used due to their large capacity size and backup power capabilities. During a black start, the system operator will designate a "cranking path," which determines the order for units to start up in different parts of the system in order to gradually restore the grid to operation. In order to maintain readiness, designated plants are frequently required to test their black start capabilities.

5.3 General Preparedness

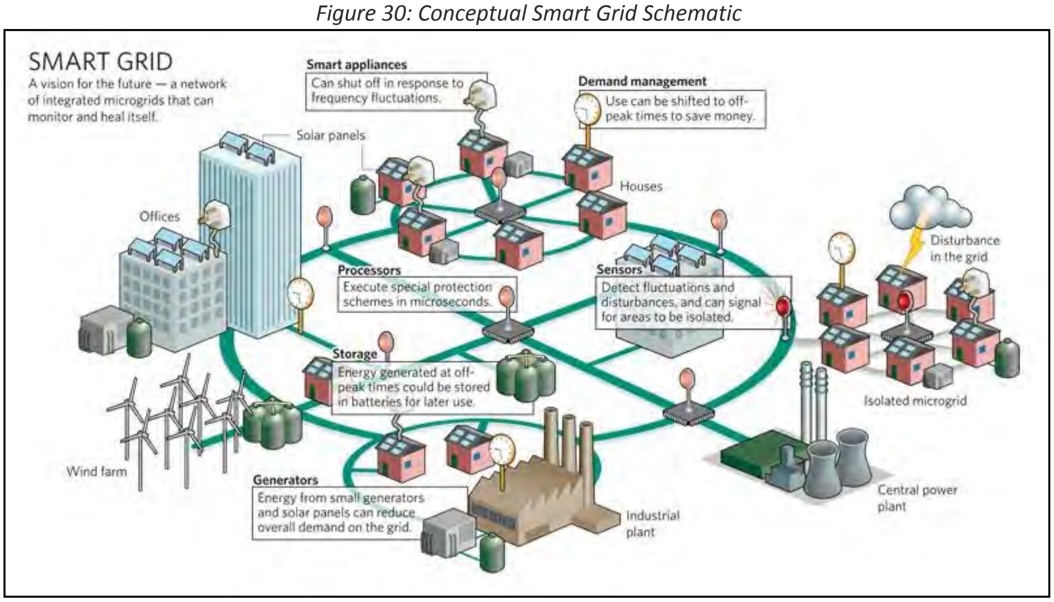
Year-round, utilities prepare for all sorts of scenarios ranging from small thunderstorms, winter snow and ice storms, hurricanes, inadequate reserves of generation, lack of fuel stocks, accidents, thefts, sabotage, and cyber-attacks. The following describes some activities utilities engage in, particularly during business-as-usual conditions, to better prepare for events.

- **Exercises:** Utilities often engage in regularly timed exercises and drills to prepare for various scenarios. These drills prepare employees and crews for what to expect during live disasters.
- **Hardening:** This is a general term to describe the physical changes to a utility's infrastructure to make it less susceptible to storm damage. Hardening can increase the durability and reliability of transmission and distribution assets, as well as generators. Undergrounding, or burying transmission and distribution lines underground, where appropriate, is one type of hardening. Undergrounding can protect lines from above-the-ground events such as storms, accidents, and even physical attacks. Underground lines, however, are expensive, more susceptible to flooding damage, and they are more difficult to repair when problems do occur. Utilities can also harden their infrastructure by modifying design elements of their assets. This includes elevating certain infrastructure like substations or designing electricity poles that are able to withstand high winds.
- **N-1 Contingency Planning:** Utilities ensure that they are able to maintain service if one or more system elements goes offline. Elements are referred to as transformers, generators, transmission and distribution lines, and other assets that are involved with the supply of electricity. In a system of "n" total elements, an "n-1" event is referred to as an event where one element or multiple *linked* (electrically or physically) elements go offline. A single element going offline is the most common—for example, when one transmission line goes out of service. The remaining operating transmission lines must be able to pick up the shut line's load and maintain reliable service. There may be cases in which a single element goes offline and others follow it. For example, when a single tower that operates two transmission lines is offline, the two lines will be subsequently unavailable. This is still referred to as an "n-1" contingency because one

element was initially out of service and two additional linked elements were unavailable as a result.

- **Vegetation Management:** Vegetation management involves the removal or trimming of trees, bushes, and other greenery that may be too close to electric infrastructure so as to potentially damage equipment during storms. There are many rules that regulate how a utility conducts vegetation management. First, a utility is required by Federal reliability standards (FERC) to maintain a certain clearance amount for service reliability and safety purposes. These apply to transmission facilities. Distribution lines that connect to local homes and business are generally governed by State utility commissions and local agencies. To maintain reliability, utilities are given a right-of-way to manage vegetation on private property. Utilities with rights-of-way on Federal lands have additional maintenance requirements from Federal land management agencies.
- **Smart Grid and Microgrid:** The development of smart grid is a form of hardening that is slowly being implemented by utilities across the country. Smart grid allows utilities to quickly identify outage areas, and use crews and resources more efficiently. Utilities can save time by avoiding having to send out personnel just to identify a problem area. A microgrid is a less common form hardening, yet still effective. A microgrid is essentially an isolated "island" of electricity generation, transmission, and distribution. Microgrids are able to disconnect from the grid and operate independently for an extended period of time. These technologies are more common in large complexes like military bases, but are gaining widespread support and development across industry and government.

Figure 30: Conceptual Smart Grid Schematic



Source: U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability

- **Inspections/Maintenance:** Utilities regularly inspect their facilities to make note of any wear and tear and any required repairs or upgrades.

- **Resiliency:** Resiliency is the ability of a utility to quickly recover from severe damage to its assets. While it may not be a preventative measure, it is important because a resilient utility can continue to operate after sustaining damage or rapidly return to normal operations. One such measure of resiliency is having a sufficient crew size with the proper training. Similarly, utilities also have a well-maintained stock of backup supplies, such as poles, lines, transformers, and backup generators. Enhanced communication and planning can serve as a great measure for resiliency. Utilities can use mobile command centers that are able to expedite response efforts. Mobile command centers can enable satellite and cellular communications and video monitoring to help coordinators allocate crews and resources to where they are needed.
- **Mutual Assistance:** Large-scale outage events affecting tens of thousands and even hundreds of thousands of customers can make the restoration process even more difficult for utilities that are affected. During such events, utility crews must make repairs at numerous damage locations and often require the assistance of outside help to expedite power restoration. This outside help comes from neighboring and regional utilities that have entered into an agreement prior to an outage event taking place. Typically, other utilities supply the affected utility with labor, materials, and specialized expertise to aid in the restoration effort. Resources could include crews that specialize in vegetation management, repairing lines, or other potential needs during an outage event. It is important to note that mutual assistance is voluntary and not-for-profit. A group of investor-owned utilities within a specific geographic area (intrastate or interstate groups are common) that have formed such agreements are called Regional Mutual Assistance Groups (RMAGs). RMAGs are crucial for resource mobilization and logistics. A Fact Box detailing RMAGs and their role in Superstorm Sandy is shown on the next page. Similarly, municipally owned and cooperatively owned utilities have also established mutual assistance contracts and plans to enact during disasters, but on much smaller scales compared to RMAGs.

5.4 Prestorm Preparation

When a storm is announced, utilities assess the situation based on the storm's forecasted path and strength. The list below provides some key items utilities must address when a storm is approaching. It is important to note that these are not necessarily done in the same order by all utilities, and most utilities have emergency restoration plans that are designed in advance and exercised regularly.

1. **Appoint Coordinator(s):** Utilities appoint a lead or leads for various functions (e.g., live wires down, restoration, vegetation management, overall communications). This may even be done during the business-as-usual period.
2. **Identifying Plan for Response to Priority 1 Calls:** Priority 1 calls refer to situations where there is an immediate threat to life or major property loss. This type of communication enables utilities and their crews to prioritize situations where damaged infrastructure threatens public safety, as well as prioritize the restoration of hospitals and other emergency services.
3. **Reviewing Critical Facility List:** This involves reassessing the critical asset list and ranking assets for restoration priority.

4. **Communications Plan:** Utilities have plans to communicate with local, State, Federal officials, local emergency responders, and members of mutual assistant groups. Utilities also maintain open communication channels with customers to inform them of safety measures, impact assessments, and restoration estimates. This may also be done during business-as-usual conditions.
5. **Identify Resources:** Utilities identify resources that are available to respond to an emergency. This includes crews, backup generators, mutual assistance, and Federal and State financial aid.

5.5 Restoration Process

When heavy storms are in the forecast, utilities begin to mobilize crews and other restoration resources. Mobile command centers are dispatched to impact areas and provide a central hub for communication and coordination for restoration efforts. Crews and equipment are also organized and pre-positioned, and mutual assistance is called upon if a storm is projected to have significant impacts. Once a storm has passed, utilities execute the following basic procedures for restoring power:

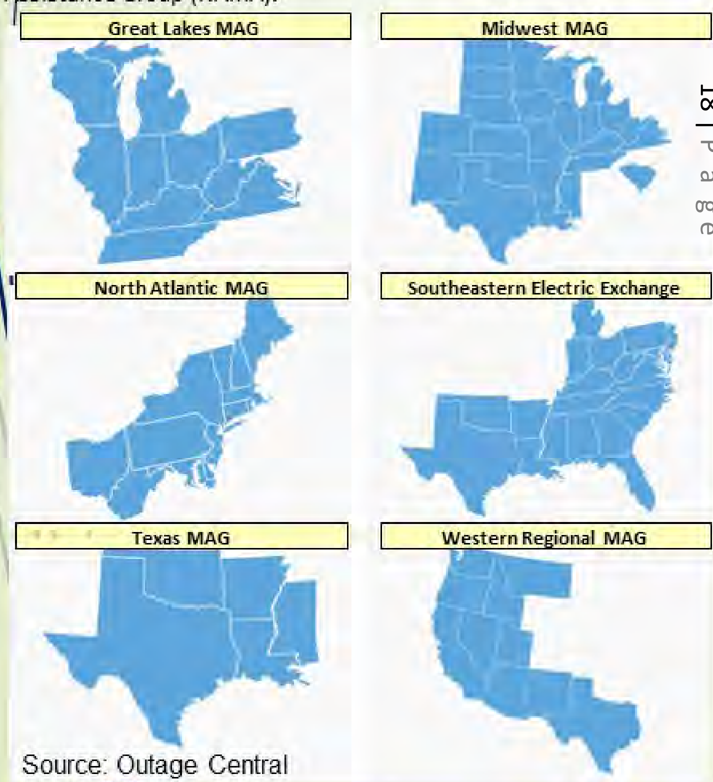
1. **Damage Assessment of Assets:** Utilities conduct a damage assessment of lines and substations. Damage assessment is done by sending out crews to inspect the service area. Utilities that have advanced smart grid technology can save time by having already identified areas that have suffered outages. Customers may also contribute to damage assessments by calling in and reporting major outages or broken lines that pose a threat to their safety. The assessment allows the utility to direct its crews and other resources to areas where they are needed the most.
2. **Eliminating Hazardous Situations:** Repairs are made to downed live wires or potentially life-threatening situations. Live damaged wires and substations are shut to prevent harm.
3. **Power Plants:** After a damage assessment, if power plants have been damaged and shut, these are usually the first to get restored as they are the electricity source.
4. **Large Transmission Lines and Substations:** Utilities then focus on large transmission lines that carry high-voltage electricity to the distribution system from generation stations or other transmission infrastructure. Lines such as these must be repaired first along with any damaged substations as they can supply power to thousands of customers.
5. **Restoring Power to Critical Infrastructure:** Power is restored to public health and safety facilities, such as hospitals, police, and fire stations.
6. **Distribution Lines and Substations:** Repairs are done to distribution substations and their respective main feeder lines, which link smaller scale customers such as neighborhoods and businesses.
7. **Individual Homes:** Power is restored to individual homes and small businesses.

Fact Box

Regional Mutual Assistance Group

U.S. Department of Energy
Office of Electricity Delivery
and Energy Reliability

- When a group of utilities within a region form a mutual assistance network, it is called a Regional Mutual Assistance Group, or RMAG. The RMAG structure is primarily used by IOUs, whereas municipal and co-op utilities have their own distinguished mutual assistance processes. RMAGs are important in that they promote safety of employees and customers, improve communication and the relationship between utilities, mitigate the risks and costs of member utilities during major events, promote the sharing of best practices, and enable a consistent and unified response to emergency events.
- Various groups can also have overlapping members, particularly when unique resources are required for certain areas. Super-storm Sandy highlighted the need for a more expansive mutual assistance program, one that goes beyond a regional scope to one that is able to respond to national response events (NREs). Following the storm, coordination began on a national level, which spanned over multiple RMAGs, as well as enhanced coordination with federal and state agencies. Several RMAGs in the Northeast combined to form the North Atlantic Mutual Assistance Group (NAMA).



Source: Outage Central

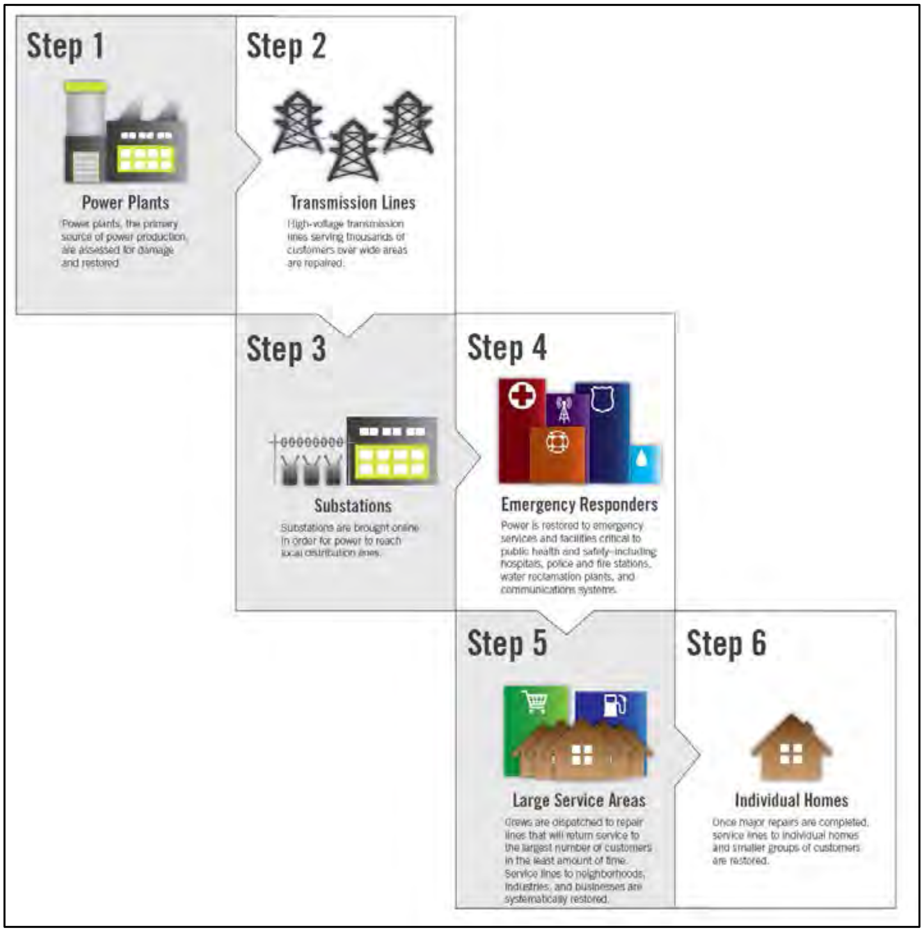
18 | P a g e

Superstorm Sandy

- 67,000 mutual assistance personnel from 80 utilities joined the restoration efforts including line-workers, support and logistics personnel, engineers, vegetation management, safety personnel, and customer service representatives
- Within two weeks, power was restored to 99 percent of customers who could receive power.
- Three PMAs, BPA, WAPA and SWPA brought in 235 staff and roughly 200 pieces of equipment for restoration. This marked the first time WAPA and SWPA engaged in mutual aid with investor-owned utilities as part of DOE's ESF-12 response. The Department of Defense helped airlift equipment from PMA facilities.
- Utilities, such as Con Edison, received resources from as far as Canada and California.

The following diagram by EEI summarizes the process:

Figure 31: Typical Power Restoration Process



Source: EEI

Often times, power restoration is not as straightforward as going through a checklist of items. For example, utilities may not restore power to certain areas or individual homes that have suffered massive damage because they deem it unsafe to do so. In such instances, property owners must hire their own electrical inspector to assess the damage and then make the necessary repairs. This was the case after Superstorm Sandy when significant damage to property delayed restoration efforts for weeks.

Timing is also very important when it comes to storm preparations. For hurricanes and tropical storms, utilities typically have more than a week to plan. This allows them ample time to mobilize their own crews as well as have additional resources on standby should they be required for extensive damage and outages. In many cases, utilities regularly conduct exercises and drills to prepare their employees for emergencies. Some severe thunderstorms, on the other hand, provide very little advance warning.

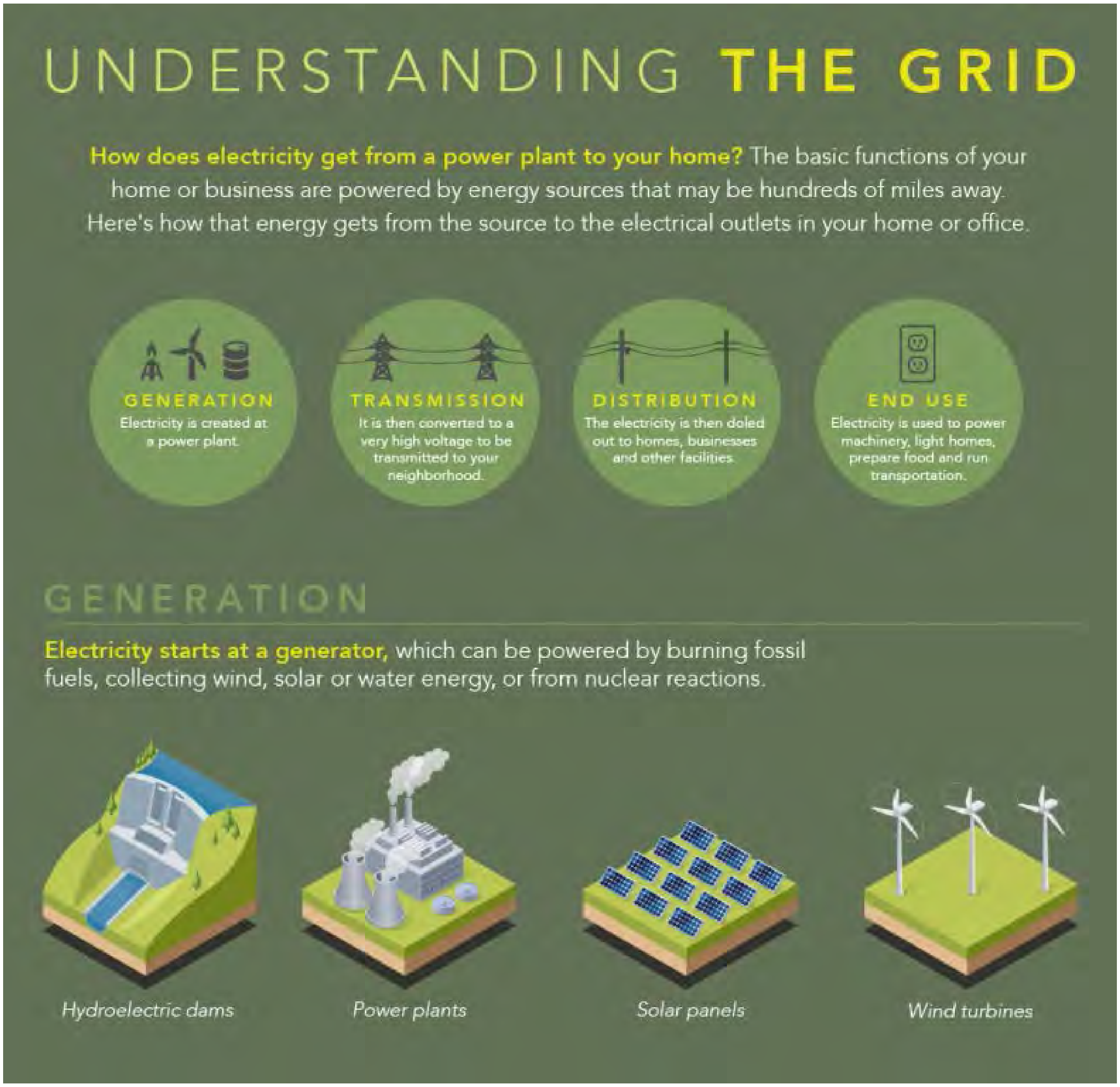
5.6 Interdependencies

Interdependency, in the general sense, is mutual dependence between entities. In the energy industry, interdependencies across various sectors, particularly in oil, gas and electric, can further complicate power restoration. The production and delivery of oil and gas heavily depends on the supply of power. The production of electricity requires the steady supply of fuels such as natural gas, coal, and oil. Furthermore, petroleum product pipelines and terminals around major hubs, petroleum product pipelines to big cities, natural gas lines to communities, and gas stations depend on a reliable supply of electricity. Water treatment facilities, pumping stations, and communication systems also rely heavily on electricity supply. Superstorm Sandy, once again, provides a case study of how interdependencies work and the problems that could arise when the power goes out. The storm shut down a substation in Manhattan, which cut power to 200,000 customers. Many of these customers were unable to receive water in their high-rise apartments because of pumping stations being shut. Superstorm Sandy also shut power to many gasoline stations throughout the Northeast. This left tens of thousands of motorists without the ability to refuel their tanks. Situations in which gasoline stations are closed can be made worse when emergency response vehicles are also scrambling to refuel. In June 2014, the U.S. Department of Energy established the first Federal regional refined petroleum product reserve called the Northeast Gasoline Supply Reserve. The Reserve holds one million barrels of gasoline and serves as a buffer for fuel supply for several days in the event of a massive storm. In addition, in October 2014, New York established a Strategic Fuel Reserve to help ensure that gasoline and diesel fuels are available to emergency responders.

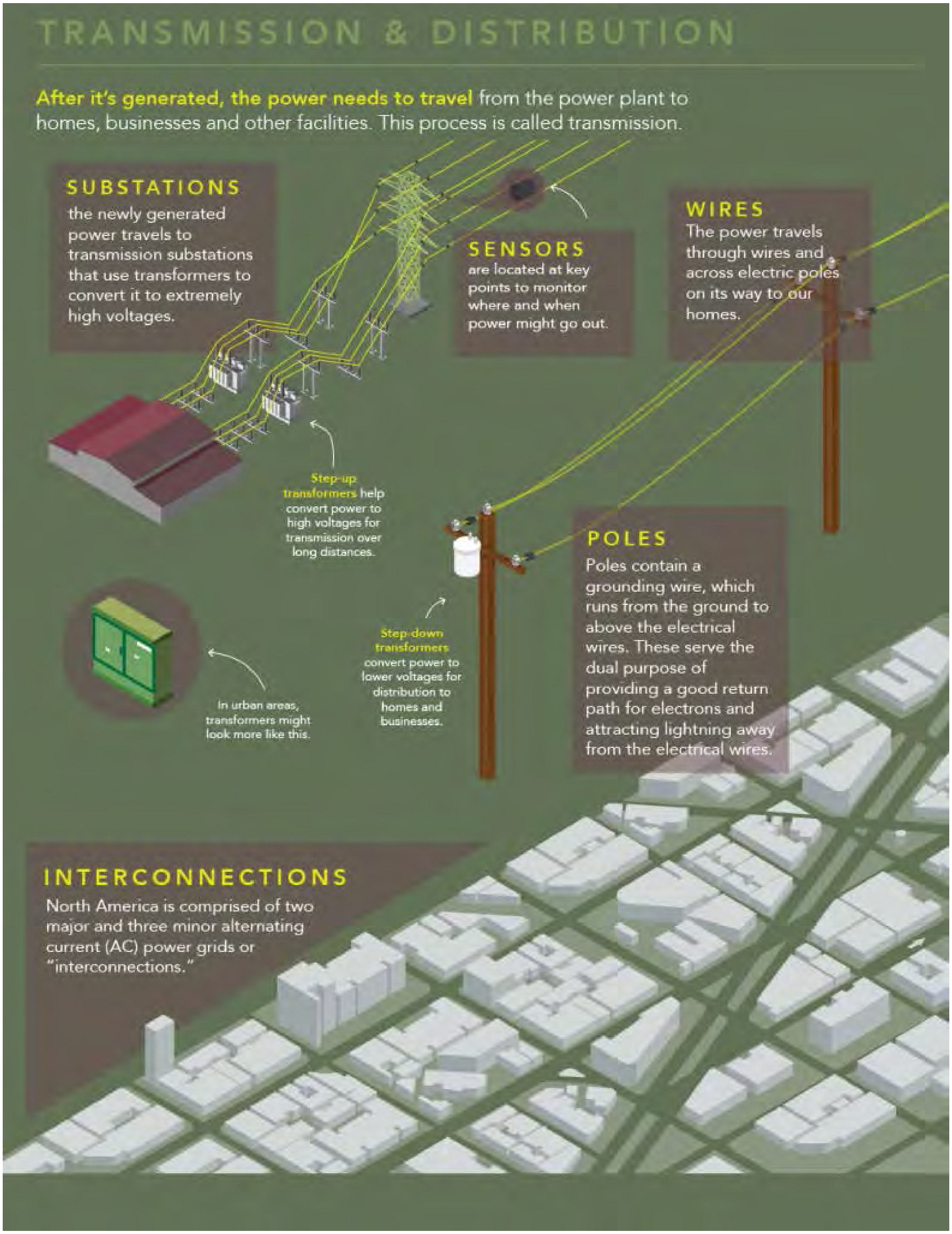
5.7 Conclusions

This document aims to provide a baseline for understanding industrial sectors of the electric power supply chain, discuss vulnerabilities to the electric grid, discuss regulatory and ownership structures, and provide context for causes of power outages and response efforts during emergencies. Several appendices further conceptualize the supply chain, explore the physics behind electrical circuits, address reliability standards, and relevant legislation. Last, a glossary of commonly used industry terms is provided to conclude the document.

APPENDIX A: UNDERSTANDING THE GRID[7]



[7] http://energy.gov/articles/infographic-understanding-grid


TRANSMISSION & DISTRIBUTION
After it's generated, the power needs to travel from the power plant to homes, businesses and other facilities. This process is called transmission.
SUBSTATIONS
the newly generated power travels to transmission substations that use transformers to convert it to extremely high voltages.
SENSORS
are located at key points to monitor where and when power might go out.
WIRES
The power travels through wires and across electric poles on its way to our homes.
Step-up transformers help convert power to high voltages for transmission over long distances.
POLES
Poles contain a grounding wire, which runs from the ground to above the electrical wires. These serve the dual purpose of providing a good return path for electrons and attracting lightning away from the electrical wires.
In urban areas, transformers might look more like this.
Step-down transformers convert power to lower voltages for distribution to homes and businesses.
INTERCONNECTIONS
North America is comprised of two major and three minor alternating current (AC) power grids or "interconnections."

END USE

Once distributed, **electricity is used to keep food cold, rooms lit and computers charged.**

ELECTRIC VEHICLES | HOMES | COMMERCIAL AREAS | INDUSTRIAL AREAS

Did you know? In 2012, the average American home used more electricity for space cooling than lighting, refrigeration or heating.

GRID INNOVATIONS

The grid is currently undergoing a major evolution with new technologies enabling shorter power outages, clean energy and energy efficiency options and providing a platform for innovative consumer services and products.

MICROGRIDS

Microgrids help distribute power, but can also disconnect from the larger grid and function as an electrical island in case there's a disruption on the grid.

ENERGY STORAGE

Energy storage technology helps integrate renewable energy into our power grid by managing the electricity supply: storing excess energy and distributing it as needed.

SMART METERS

Smart meters enable two-way communication between consumers and utility companies. This allows utilities to immediately know when your power is out enabling faster restoration.

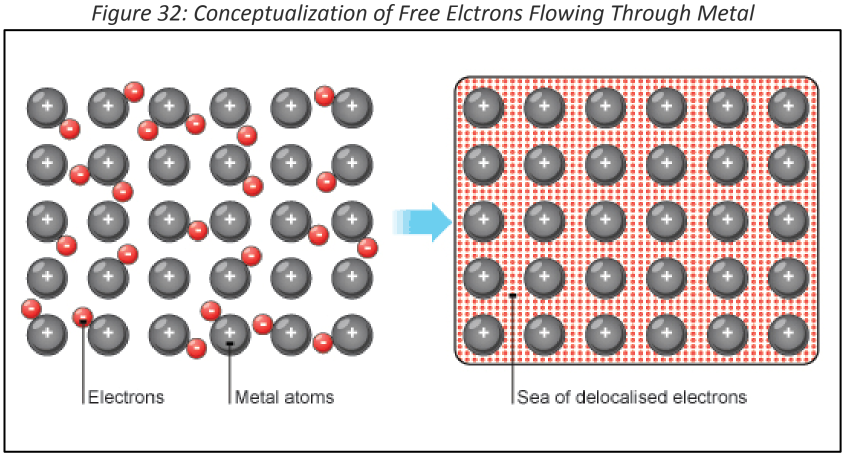
APPENDIX B: CIRCUIT BASICS

Electric Circuits

In a closed circuit, the flow of electrical current (I), must be induced by an electromotive force, or voltage (V). Circuit voltage is analogous to a pressure head of water in which current represents the flow of water. The opposition to current flow through a load, or electronic device is measured by the device's resistance (R). Ohm's law proves these metrics are proportional, in that V = IR, a common equation used for analyzing electric circuits.

Electricity flows through conductive materials such as metals, as well as water, which is an excellent electricity conductor. At the microscopic level, conductive, metallic materials such as copper and tin are three-dimensionally arranged in a cubed matrix of metallic atoms (illustrated in two dimensions in the graphic below). The electrons in orbital shells closest to the nucleus (not shown below) have strong bond attractions to positive protons in the atom's nucleus. The magnitude of bond attraction is a function of distance between the two opposite charges. The valence electrons in the outermost shells of metallic atoms (shown below) are under weak forces of attraction due to greater distances from positive charges, and can be transferred, under a voltage condition to form a sea of free-flowing, delocalized electrons.

Figure 32: Conceptualization of Free Elctrons Flowing Through Metal



Source: British Broadcasting Corporation

Units of Electric Power

Electricity is measured by units of power called watts (W). Kilowatts (kW) and megawatts (MW) are more realistic throughout industry in describing power units of larger scales such as a generator or a home. The larger the wattage of an electrical device or load, the more power it consumes—or produces in the case of a generator or power plant.

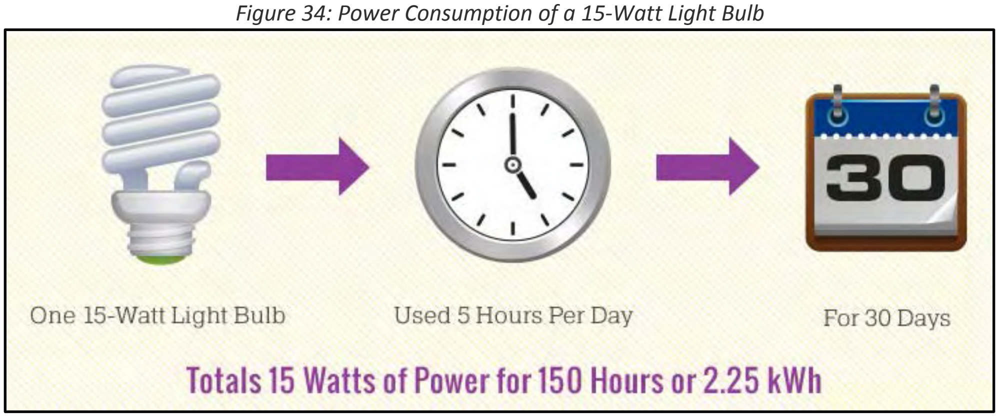
Figure 33: Electricity Terms, Derivations, and Conversions

Common Terms & SI Notation		Derivations	Unit Conversions	
Voltage: Volt [V]	Power: Watt, [W] = [V·A]	Voltage, V = IR	1 kW = 1,000 W	1 kV = 1,000 V
Current: Ampere [A] or [I]	Reactive Power: Volt-Ampere [VAR]	Power, P = IV	1 MW = 1,000 kW	1 MV = 1,000 kV
Resistance: Ohm, [Ω]	Power Delivery: Kilowatt hour, [kWh]	Power Delivery = P = PΔT	1 GW = 1,000 MW	

Source: U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability

The consumption of electric power over a period of time (delta T, [ΔT]) is expressed in kilowatt hours (kWh). For example, a 15 watt light bulb that stays lit for 5 hours a day, over a span of a month, will consume 2,250 watt hours, or 2.25 kWh of electricity. While consumption varies with respect to seasonality, time of day, and location, a typical home consumes around 900 kWh per month.

Figure 34: Power Consumption of a 15-Watt Light Bulb



Source: EEI

Alternating Current

The majority of America's power infrastructure operates synchronously on alternating current (AC). Alternating current is generated in phases, meaning that the source of voltage and current has three components changing direction periodically with time. For power systems in North American, the standard operating frequency is three-phase power generation at cycles of 60 Hertz (Hz). The figure below conceptually illustrates a three-phase AC generator and a representation of its voltage output over time. As the magnet rotates on a fixed axis within the generator, a dynamic current is generated within each coil, proportional to direction and speed of the magnetic field's rotation.

The presence of a magnetic field induces electrical currents and voltages that are directionally dependent due to the rotation of the magnetic field. In a power system, voltage and current can encounter elements that influence their directions out of synchrony, or out of phase, and during this occurrence in the cycle, electrical current is not transferred to the load as working current. These types of loads are considered to be reactive elements, and the currents they absorb, which are not utilized for useful work are known as reactive power.

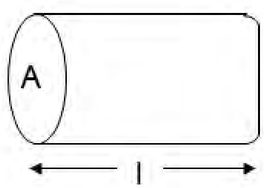
In a purely resistive AC circuit, no reactive elements exist and the voltage and current are fully in phase, meaning that power, the product of voltage and current, has a net positive value over an entire cycle, and all extractable, working current is consumed at the resistive load. In addition to resistive loads, realistic circuits also contain capacitive and inductive loads in which current flow is out of phase with voltage, meaning that a net transfer of positive working current is not delivered to the load over a full cycle; moreover, negative work transfer, or reactive power, is absorbed at the load and transferred back to the system.

In reality power has two directionally dependent current components, and is quantified as a vector sum of the active and reactive powers, known as complex, or apparent power. Transmission engineers must account for apparent power because even though reactive current performs no useful work at the load, it dissipates heat into the load and wastes energy. Conductors, transformers and generators must be sized and designed appropriately to conduct and withstand the total current, not just the portion that performs useful work.

Resistivity

Resistance depends on the *resistivity*, ρ, of the material and the length and cross-sectional area of the resistor.

$$R = \frac{\rho l}{A}$$



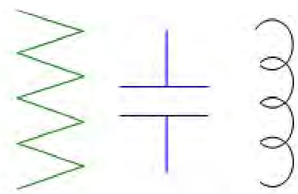
Material	*% Conductivity**
Aluminum, 99.5% pure	63.0
Copper, IACS (annealed)	100.0
Gold, 99.9% pure	72.6
Iron wire, EBB grade	16.2
Nickel	12.9
Platinum, pure	14.6
Silver, pure annealed	108.8
Steel wire	11.6
Tin, pure	12.2
Zinc, very pure	27.7

** Ratio of a substance's conductivity to the conductivity of standard copper.*

Note: Resistivity depends on temperature. For most conductors, it increases with temperature, since electron movement through a lattice becomes increasingly difficult at higher temperatures.

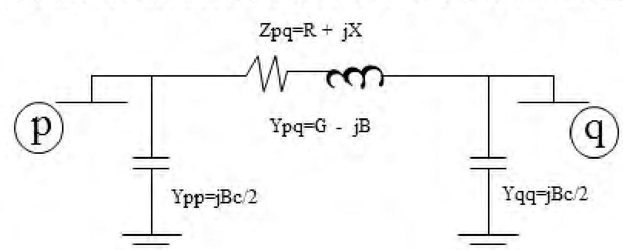
Three Passive Elements

- Resistors & Resistance:
  Heating and Lighting Loads
- Capacitors & Capacitance:
  Power Factor Correction and Voltage Support
- Inductors (or Reactors) and Inductance:
  Motor Loads



- All electric equipment has these three properties to a greater or lesser extent

- Loads and overhead transmission tend to be inductive:



Pi-Equivalent Model of a Transmission Line

Energy

E – Energy (Joules): stored work

Energy can be neither created nor destroyed – it can only be transformed (converted) from one form to another. Power plants are simply energy conversion facilities.

Some Energy Transformations

Home furnace using fuel oil, gas, or wood	Chemical to thermal and thermal to radiant
Automobile engine	Thermal to mechanical
Electric motor	Electrical to mechanical
Toaster, light bulb	Electrical to radiant
Sunlight warms ground	Radiant to thermal

Energy of Familiar Phenomena (MJ)

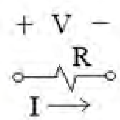
Bowling ball dropped 3 feet	0.000065
1 pound TNT	2
1 pound bread	5
1 person-day nutrition (2500 kcal)	10
1 gallon gasoline	130
Average lightning stroke	1,500
Average summer thunderstorm	160,000,000
1-GWe power plant running 1 day	260,000,000
Hydrogen bomb (1 megaton)	4,000,000,000

Power

Power (Watts): rate at which energy changes form or location

$$P = VI = (IR)I = I^2 R$$

One watt is the power dissipated by a current of 1 ampere flowing across a resistance of 1 ohm.

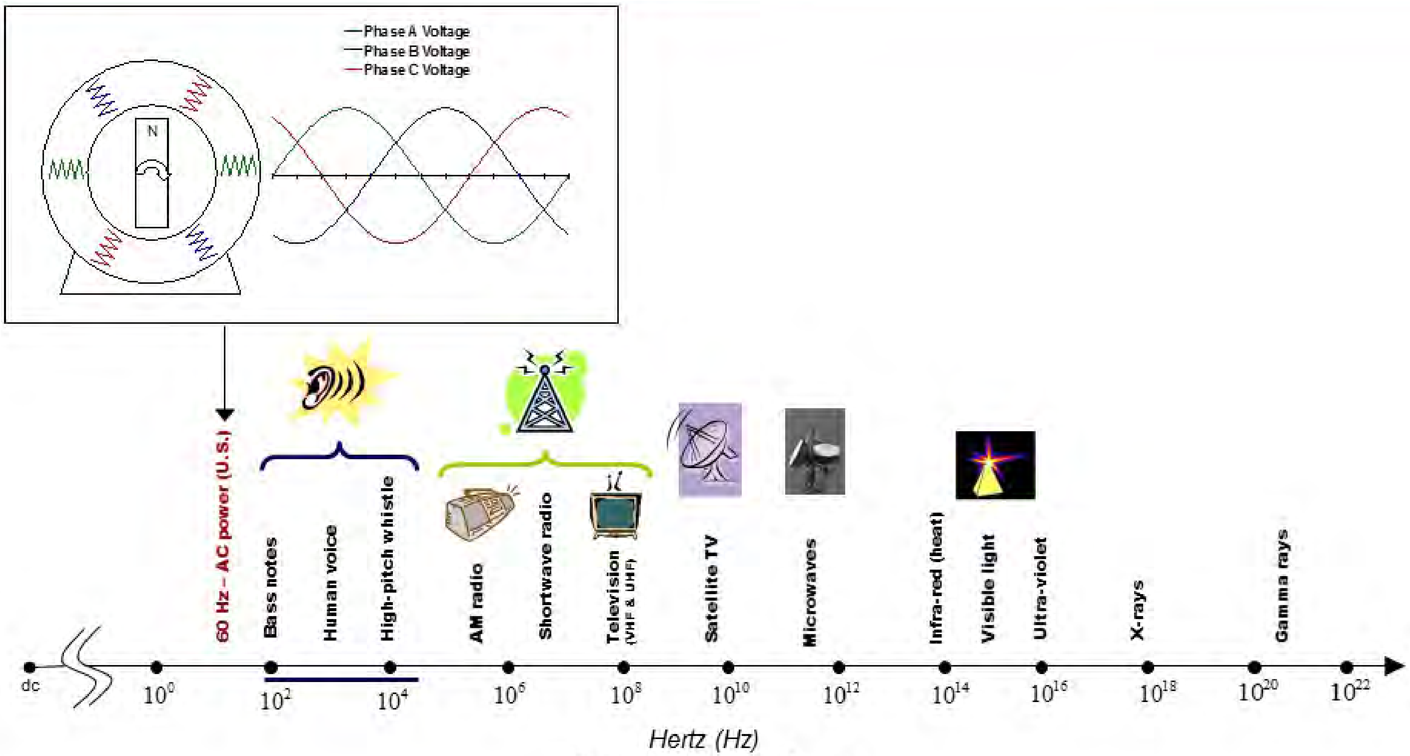


A *Kilowatt Hour (kWh)* is the unit by which residential and most business customers are billed for monthly electric use. It represents the use of one kilowatt (1,000 watts) of electricity for one hour, or a 100 watt light bulb burning for 10 hours. The average U.S. household uses 10.7 MWh (10,700 kWh) of electricity every year.

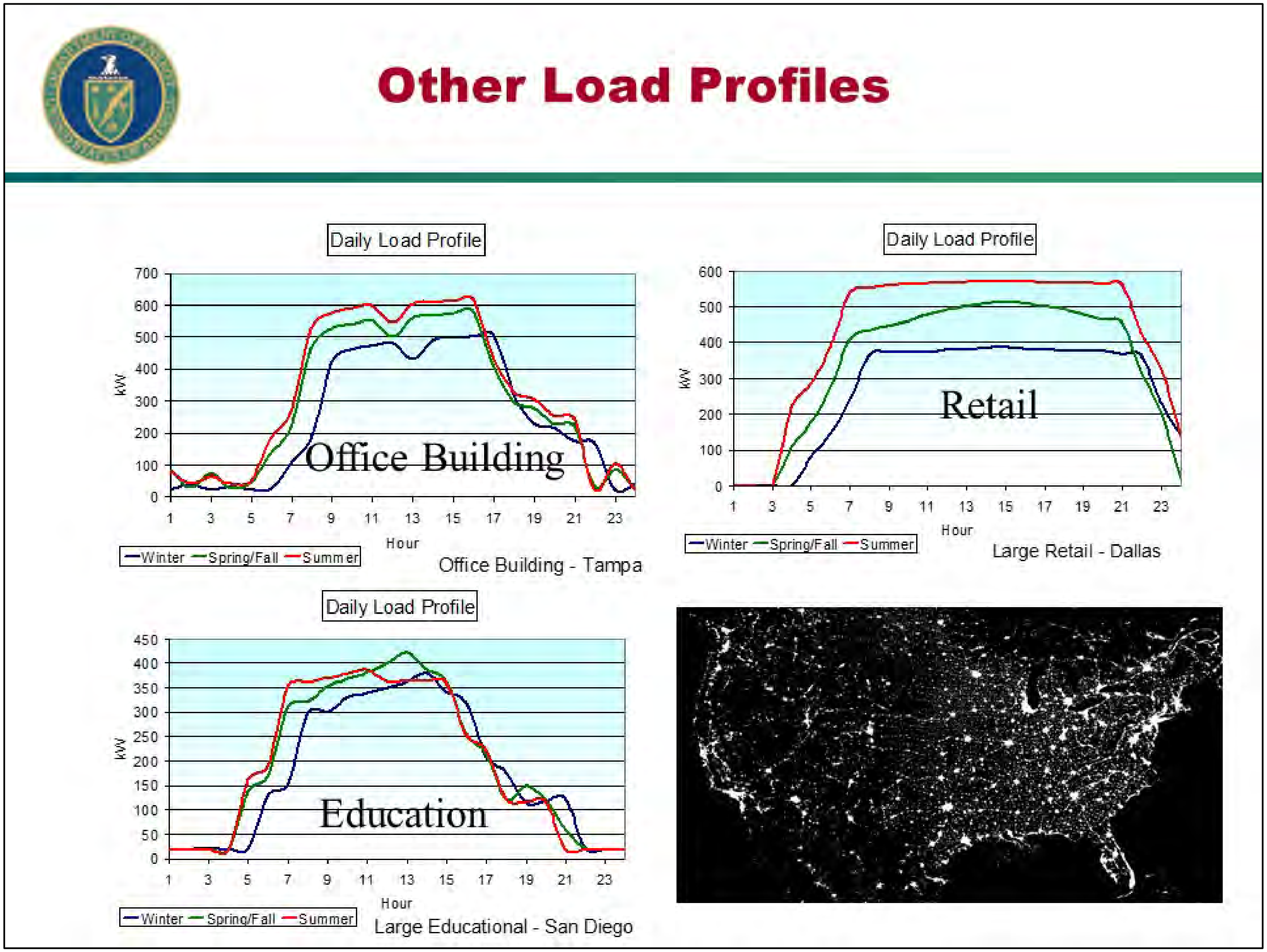
Customer Size

		kWe
Industrial	Semiconductor Manufacturer	30,000+
	Plastics Plant	20,000+
	Paper Mill	5,000+
Large Commercial	Shopping Mall/ Large Office Bldg	3,000+
	Food Processing	2,500
	Hospital	500 - 1,000
	Hotel	250 - 500
Small Commercial	Small Office Bldg	100
	Gas Station/ Fast food	75
Residential	Multi-family	5 - 50
	Home	2 - 25

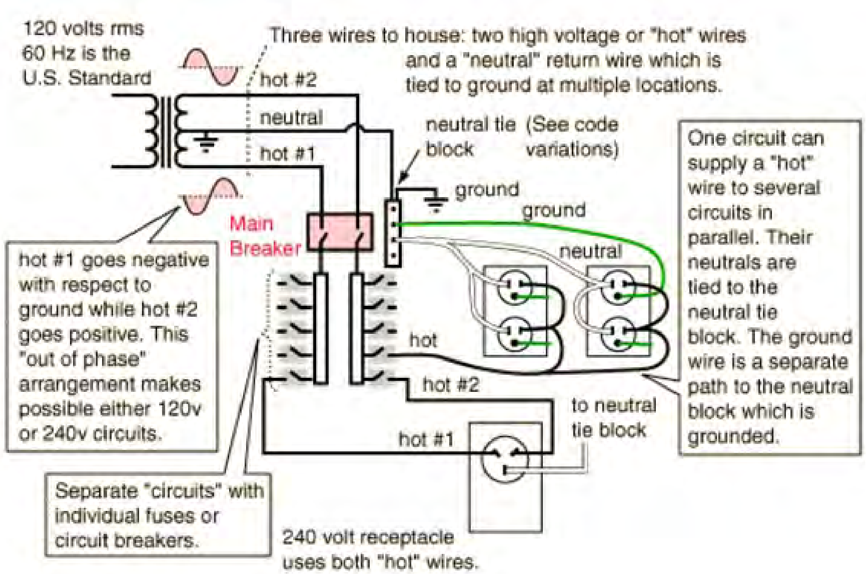
Frequency



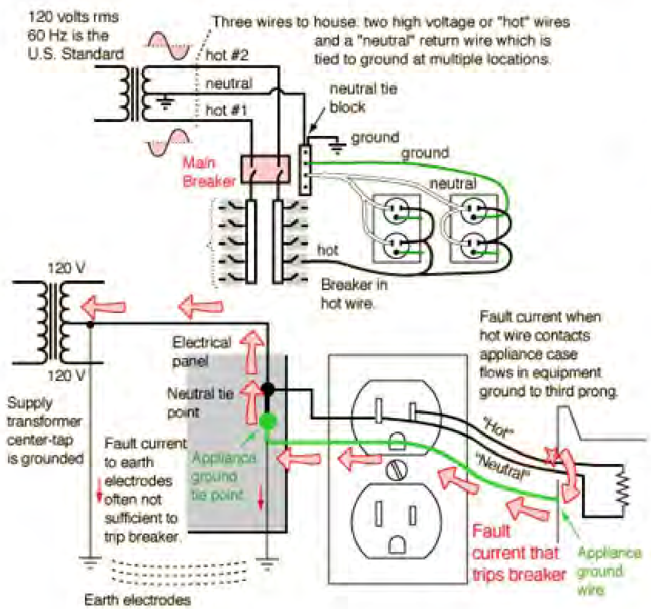
Frequency Spectrum

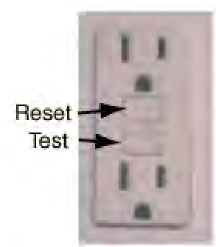

Other Load Profiles
Daily Load Profile
700
600
500
400
300
200
100
0
kW
1 3 5 7 9 11 13 15 17 19 21 23
Hour
Office Building
Winter Spring/Fall Summer
Office Building - Tampa
Daily Load Profile
600
500
400
300
200
100
0
kW
1 3 5 7 9 11 13 15 17 19 21 23
Hour
Retail
Winter Spring/Fall Summer
Large Retail - Dallas
Daily Load Profile
450
400
350
300
250
200
150
100
50
0
kW
1 3 5 7 9 11 13 15 17 19 21 23
Hour
Education
Winter Spring/Fall Summer
Large Educational - San Diego

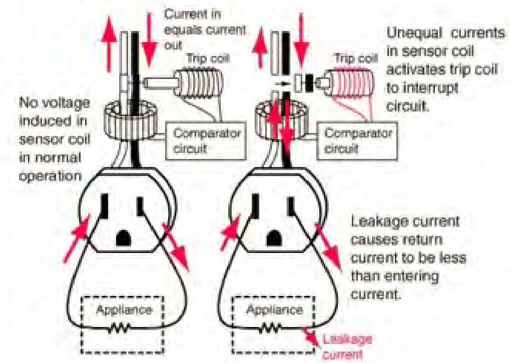
Household Wiring



Ground Faults



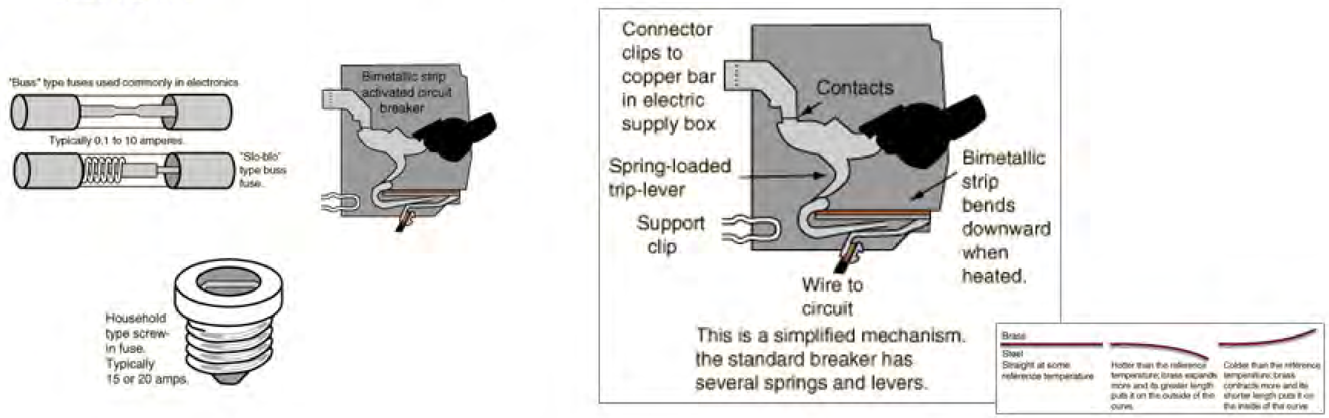




Electric Current (1 second contact)	Physiological Effect
1 mA	Threshold of feeling, tingling sensation.
10-20 mA	"Can't let go!" current - onset of sustained muscular contraction.
100-300 mA	Ventricular fibrillation, fatal if continued

Fuses and Breakers

- Fuses and breakers limit the current which can flow in a circuit. The metal filament in the fuse melts and breaks the connection, whereas in a breaker, the heating effect on a bimetallic strip causes it to bend and trip a spring-loaded switch.

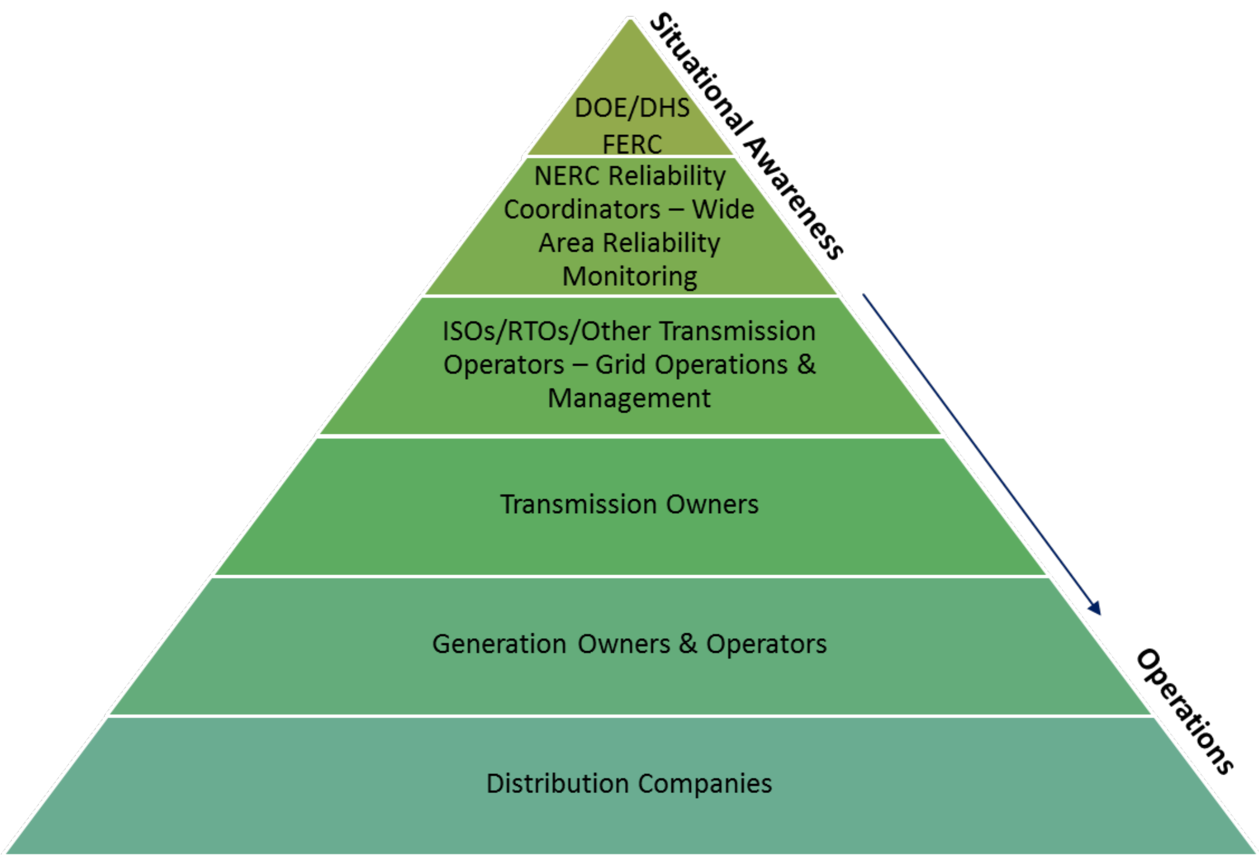


APPENDIX C: RELIABILITY STANDARDS

Electric Reliability

The Northeast Blackout of 2003 created an urgent need for a new set of rules that would help prevent similar mass outages. The Energy Policy Act of 2005 authorized FERC to designate a national ERO. In 2006, FERC issued an order establishing NERC as the ERO for the United States. Prior to being the National ERO, NERC's guidelines for power system operations and planning were not mandatory, only strongly encouraged and voluntary. NERC worked to develop reliability standards, and was given the authority to enforce those standards through monetary and non-monetary penalties. The following figure shows the authorities responsible for electric reliability in the United States.

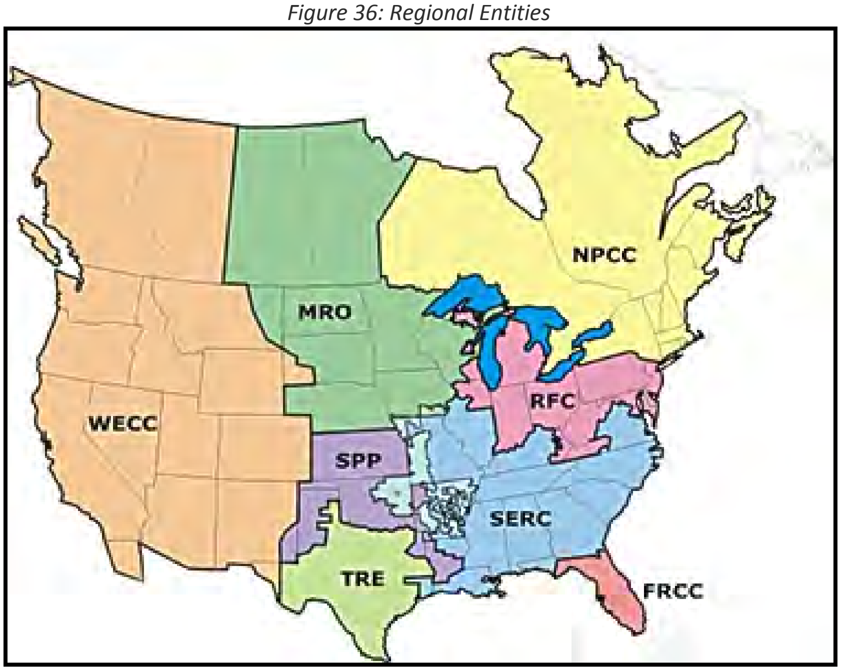
Figure 35: Hierarchy of Electric Reliability Monitoring



Source: Department of Homeland Security

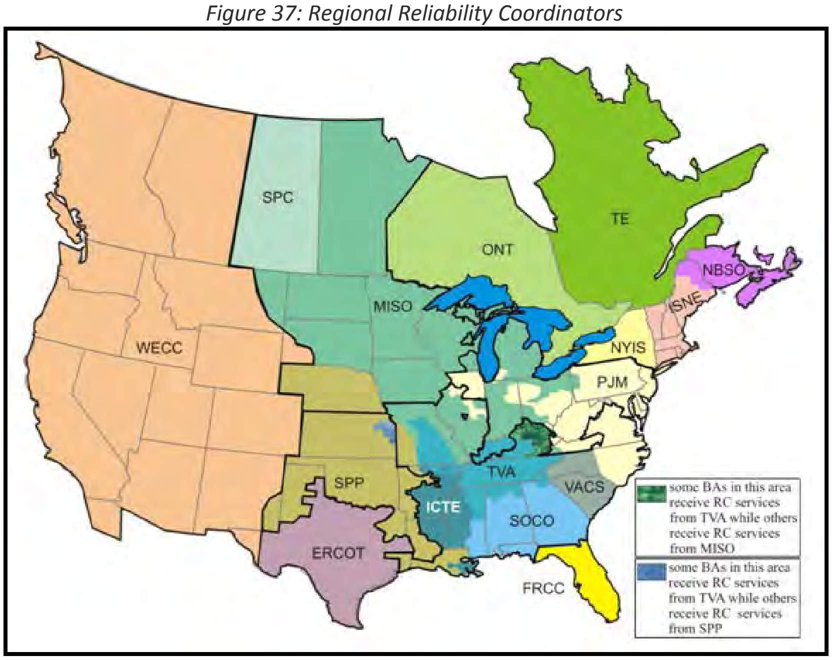
NERC uses Regional Entities (RE) to enforce its standards. Within each RE boundary there are one or more NERC-certified reliability coordinators. Figures 36 and 37 show the REs and Reliability Coordinators in North America. Reliability Coordinators are charged with the task of continuously monitoring the reliability of the transmission system. The coordinator has the authority to direct stakeholders (transmission operators, generators, and others that are involved with the electric grid's operations) to take action to preserve safe and reliable operation of the grid.

Figure 36: Regional Entities



Source: NERC

Figure 37: Regional Reliability Coordinators



Source: NERC

NERC Reliability Standards are summarized here:

1. **Supply and Demand Balancing:** Maintaining the supply and demand balance under business as usual conditions and making sure the grid is prepared for emergency situations
2. **Transmission Operations:** Ensuring that all Reliability Standards are followed by grid operators that coordinators and operators have the resources needed to address grid issues, and procedures are in place to resolve threats to the system
3. **Transmission Planning:** Ensuring that new transmission facilities are resilient to threats and emergencies
4. **Communication:** maintaining proper communication and coordination between reliability coordinators and operators of the grid
5. **Critical Infrastructure Program:** Ensuring that the grid's critical assets as protected from cyber and physical threats
6. **Emergency Preparedness:** Ensuring that grid operators are prepared for emergencies, and have the resources and authority to restore operations if there is a disruption
7. **Facilities Design, Connections and Maintenance:** Ensuring that transmission operators have properly rated their transmission equipment and that adequate maintenance is performed to maintain grid reliability
8. **Interchange Scheduling and Coordination:** Ensuring that electricity transmission between balancing authorities does not pose a threat to the grid
9. **Interconnection Reliability Operations and Coordination:** Making sure that reliability coordinators have the authority to enforce reliability by directing grid operators to take necessary action when a threat is perceived
10. **Data Analysis:** Making sure that grid operators are using accurate and consistent data for the use of transmission planning and reliability
11. **Nuclear Operations:** Making sure that there is proper coordination between nuclear plant and transmission operators
12. **Personnel Training:** Ensuring that grid operations personnel are properly trained and qualified to meet the Reliability Standards
13. **Protection and Control:** Ensuring that protection systems that protect the grid are operating as designed
14. **Voltage:** Ensuring that reactive power sources operate within their limits and maintain adequate voltage levels

Planning Reserve Margin

To ensure reliability of the electric system, REs establish regional reserve margin targets for entities within the RE footprint. Reserve margin is the percent of generation capacity that is above peak demand, thus having more supply than may be required. Calculated, reserve margin is (available capacity minus demand)/demand. For example, a reserve margin of 15 percent means that an electric system has excess capacity in the amount of 15 percent above the peak demand.

APPENDIX D: U.S. DEPARTMENT OF ENERGY AUTHORITIES AND KEY LEGISLATION

DEFENSE PRODUCTION ACT OF 1950 (DPA), as amended
64 Stat. 798 (1950) 50 U.S.C. app. §§ 2061-2170

The DPA serves as the primary authority to ensure the timely availability of resources for national defense and civil emergency preparedness and response. Sections 101(a), 101(c), and 708, 50 U.S.C. §§ 2071 (a), (c), 2158, authorizes the President to require companies to accept and give priority to contracts or orders that the President "*deems necessary or appropriate to promote the national defense.*" The DPA defines "national defense" to include critical infrastructure protection and restoration, as well as activities authorized by the emergency preparedness sections of the Stafford Act. Consequently, the DPA authorities are available for activities and measures undertaken in preparation for, during, or following a natural disaster or accidental or man-made event.

The Secretaries of Energy and Commerce have been delegated the President's authorities under sections 101(a) and 101(c) of the DPA to require the priority performance of contracts or orders relating to materials (including energy sources), equipment, or services, including transportation, or to issue allocation orders, as necessary or appropriate for the national defense or to maximize domestic energy supplies. DPA section 101(a) permits the priority performance of contracts or orders necessary or appropriate to promote the national defense. "*National defense*" is defined in DPA section 702(13) to include "*emergency preparedness activities conducted pursuant to title VI of the Robert T. Stafford Disaster Relief and Emergency Act and critical infrastructure protection and assurance.*"

The Secretary of Energy has been delegated (Executive Orders 12919 and 11790) DPA section 101(a) authority with respect to all forms of energy. The Secretary of Commerce has been delegated (Executive Order 12919) the section 101(a) authority with respect to most materials, equipment, and services relevant to repair of damaged energy facilities. Section 101(c) of the DPA authorizes contract priority ratings relating to contracts for materials (including energy sources), equipment, or services to maximize domestic energy supplies, if the Secretaries of Commerce and Energy, exercising their authorities delegated by Executive Order 12919, make certain findings with respect to the need for the material, equipment, or services for the exploration, production, refining, transportation, or conservation of energy supplies.

DPA priority contracting and allocation authorities can be used to expedite repairs to damaged energy facilities, and for other purposes, including directing the supply or transportation of petroleum products, to maximize domestic energy supplies, meet defense energy needs, or support emergency preparedness activities. In the case of both the section 101(a) and 101(c) authorities, if there are contracts in place between the entity requiring priority contracting assistance and one or more suppliers of the needed good or service, DOE (with respect to the section 101(c) authority) or DOC (with respect to the section 101(a) authority) would issue an order requiring suppliers to perform under the contract on a priority basis before performing other non-rated commercial contracts. If no contracts are in place, DOE or DOC would issue a directive authorizing an entity requiring the priority contracting assistance to place a rated order with a supplier able to provide the needed materials, equipment, or services. That contractor would be required to accept the order and place it ahead of other nonrated commercial orders.

Section 705 authorizes the President to subpoena or otherwise obtain information from any person as may be appropriate, in his discretion, to the enforcement or administration of the DPA (50 U.SC § 2155). Through Executive Order 13603, DOE has delegated Section 705 authority.

DPA section 708 provides a limited antitrust defense for industry participating in voluntary agreements "*to help provide for the defense of the United States through the development of preparedness programs and the expansion of productive capacity and supply beyond levels needed to meet essential civilian demand in the United States.*" In the event of widespread damage to energy production or delivery systems, this authority could be used to establish a voluntary agreement of service companies to coordinate the planning of the restoration of the facilities.

DEPARTMENT OF ENERGY ORGANIZATION ACT AND FEDERAL POWER ACT

Pub. L. No. 95-91, 91 Stat. 567 and 16 U.S.C. §§ 791a-828c, 10 C.F.R. §§ 205.350, 205.353

DOE has authority to obtain current information regarding emergency situations on the electric supply systems in the United States. DOE has established mandatory reporting requirements for electric power system incidents or possible incidents. This reporting is required to meet DOE's national security requirements and other responsibilities (e.g., OE-417 Electric Emergency Incident and Disturbance Reports).

Section 645 of the DOE Organization Act provides DOE with subpoena power for purposes of carrying out responsibilities under the DOE Organization Act and the Federal Energy Regulatory Commission with respect to the Natural Gas Policy Act of 1978 (42 U.S.C. § 7255).

ENERGY POLICY AND CONSERVATION ACT (EPCA)
42 U.S.C. 6201-6422

Provides for the establishment of the Strategic Petroleum Reserve
"§ 6231. Congressional finding and declaration of policy
(a) The Congress finds that the storage of substantial quantities of petroleum products will diminish the vulnerability of the United States to the effects of a severe energy supply interruption, and provide limited protection from the short-term consequences of interruptions in supplies of petroleum products.
(b) It is the policy of the United States to provide for the creation of a Strategic Petroleum Reserve for the storage of up to 1 billion barrels of petroleum products to reduce the impact of disruptions in supplies of petroleum products, to carry out obligations of the United States under the international energy program, and for other purposes as provided for in this chapter."

Directs the Secretary of Energy to establish, operate, and maintain the Strategic Petroleum Reserve

"§ 6234. Strategic Petroleum Reserve
(a) Establishment
A Strategic Petroleum Reserve for the storage of up to 1 billion barrels of petroleum products shall be created pursuant to this part.
(b) *Authority of Secretary*
The Secretary, in accordance with this part, shall exercise authority over the development, operation, and maintenance of the Reserve."
"§ 6239. Development, operation, and maintenance of the Reserve
(f) Powers of Secretary to develop and operate the Strategic Petroleum Reserve
In order to develop, operate, or maintain the Strategic Petroleum Reserve, the Secretary may—
(1) issue rules, regulations, or orders;
(2) acquire by purchase, condemnation, or otherwise, land or interests in land for the location of storage and related facilities;
(3) construct, purchase, lease, or otherwise acquire storage and related facilities;
(4) use, lease, maintain, sell or otherwise dispose of land or interests in land, or of storage and related facilities acquired under this part, under such terms and conditions as the Secretary considers necessary or appropriate;
(5) acquire, subject to the provisions of section 6240 of this title, by purchase, exchange, or otherwise, petroleum products for storage in the Strategic Petroleum Reserve;
(6) store petroleum products in storage facilities owned and controlled by the

United States or in storage facilities owned by others if those facilities are subject to audit by the United States;
(7) execute any contracts necessary to develop, operate, or maintain the Strategic Petroleum Reserve;
(8) bring an action, when the Secretary considers it necessary, in any court having jurisdiction over the proceedings, to acquire by condemnation any real or personal property, including facilities, temporary use of facilities, or other interests in land, together with any personal property located on or used with the land."

Provides for the Presidentially-directed drawdown of the Reserve through the Secretary of Energy

"§ 6241. Drawdown and sale of petroleum products
(a) Power of Secretary
The Secretary may drawdown and sell petroleum products in the Reserve only in accordance with the provisions of this section."
"(d) Presidential finding prerequisite to drawdown and sale
(1) Drawdown and sale of petroleum products from the Strategic Petroleum Reserve may not be made unless the President has found drawdown and sale are required by a severe energy supply interruption or by obligations of the United States under the international energy program.
(2) For purposes of this section, in addition to the circumstances set forth in section 6202(8) of this title, a severe energy supply interruption shall be deemed to exist if the President determines that—
(A) an emergency situation exists and there is a significant reduction in supply which is of significant scope and duration;
(B) a severe increase in the price of petroleum products has resulted from such emergency situation; and
(C) such price increase is likely to cause a major adverse impact on the national economy."
"(8) The term ''severe energy supply interruption'' means a national energy supply shortage which the President determines—
(A) is, or is likely to be, of significant scope and duration, and of an emergency nature;
(B) may cause major adverse impact on national safety or the national economy; and
(C) results, or is likely to result, from (i) an interruption in the supply of imported petroleum products,
(ii) an interruption in the supply of domestic petroleum products, or (iii) sabotage or an act of God."

Authorizes the Secretary to establish the Northeast Home Heating Oil Reserve

"§6250. Establishment
(a) Notwithstanding any other provision of this chapter, the Secretary may establish, maintain, and operate in the Northeast a Northeast Home Heating Oil Reserve."

"§ 6250a. Authority
To the extent necessary or appropriate to carry out this part, the Secretary may—
(1) purchase, contract for, lease, or otherwise acquire, in whole or in part, storage and related facilities, and storage services;
(2) use, lease, maintain, sell, or otherwise dispose of storage and related facilities acquired under this part;"

ENERGY SUPPLY AND ENVIRONMENTAL COORDINATION ACT OF 1974 (ESECA)
15 U.S.C. § 796

ESECA authorizes the Federal Energy Administrator (precursor to DOE Secretary) to prohibit any power plant and other major fuel burning installation from burning natural gas if the Administrator determines that such facility has the capability and necessary plant equipment to burn coal.

Section 11 of ESECA authorizes DOE to issue subpoenas and require answers to interrogatories within DOE-determined deadlines in order to obtain reliable energy information to assist in the formulation of energy policy and to meet the essential needs of the United States for fuels.

FEDERAL ENERGY ADMINISTRATION ACT OF 1974, SECTION 13
(Pub. L. No. 93-275, 15 U.S.C. 761 et seq.)

Grants DOE the authority to collect, assemble, evaluate, and analyze energy information

"INFORMATION-GATHERING POWER
SEC. 13. (a) The Administrator shall collect, assemble, evaluate, and analyze energy information by categorical groupings, established by the Administrator, of sufficient comprehensiveness and particularity to permit fully informed monitoring and policy guidance with respect to the exercise of his functions under this Act.
(b) All persons owning or operating facilities or business premises who are engaged in any phase of energy supply or major energy consumption shall make available to the Administrator such information and periodic reports, records, documents, and other data, relating to the purposes of this Act, including full identification of all data and projections as to source, time, and methodology of development, as the Administrator may prescribe by regulation or order as necessary or appropriate for the proper exercise of functions under this Act.
(c) The Administrator may require, by general or special orders, any person engaged in any phase of energy supply or major energy consumption to file with the Administrator in such form as he may prescribe, reports or answers in writing to such specific questions, surveys, or questionnaires as may be necessary to enable the Administrator to carry out his functions under this Act.

Such reports and answers shall be made under oath, or otherwise, as the Administrator may prescribe, and shall be filed with the Administrator within such reasonable period as he may prescribe…."

The Federal Energy Administration was terminated and functions vested by law in the Administrator thereof were transferred to the Secretary of Energy (unless otherwise specifically provided) by sections 7151(a) and 7293 of Title 42, The Public Health and Welfare.

FEDERAL POWER ACT, Sections 202(a) (c), 202(e), and 206(d), as amended
(16 U.S.C. § 824a (e))

Under Section 202(a) and the Public Utility Regulatory Policies Act, Section 209(b), the Secretary of Energy has authority with regard to reliability of the interstate electric power transmission system.

FERC has the authority to define reliability regions and encourage interconnection and coordination within and between regions. DOE also has the authority to gather information regarding reliability issues and to make recommendations regarding industry security and reliability standards.

Under Section 202(c), the Secretary of Energy has authority in time of war or other emergency to order temporary interconnections of facilities and generation, delivery, interchange, or transmission of electric energy that the Secretary deems necessary to meet an emergency.

"202(c) Temporary connection and exchange of facilities during emergency

*During the continuance of any war in which the United States is engaged, or whenever the Secretary of Energy determines that an emergency exists by reason of a sudden increase in the demand for electric energy, or a shortage of electric energy or of facilities for the generation or transmission of electric energy, or of fuel or water for generating facilities, or other causes, the Secretary of Energy shall have authority, either upon his own motion or upon complaint, with or without notice, hearing, or report, to require by order such temporary connections of facilities and such generation, delivery, interchange, or transmission of electric energy as in his judgment will best meet the emergency and serve the public interest. If the parties affected by such order fail to agree upon the terms of any arrangement between them in carrying out such order, the Secretary of Energy, after hearing held either before or after such order takes effect, may prescribe by supplemental order such terms as he finds to be just and reasonable, including the compensation or reimbursement which should be paid to or by any such party."**

**Although the text of Section 202(c) actually refers to "the Commission", rather than the "Secretary of Energy", authority under that provision resides with the Secretary of Energy, rather than the Federal Energy Regulatory Commission ("FERC"). Under Section 301(d) of the Department of Energy Organization Act (the "DOE Act"), 42 U.S.C. § 7151(b) (2006), the powers previously vested in the Federal Power Commission under the FPA (and other statutes) and not expressly reserved to FERC were transferred to, and vested in, the Secretary of Energy.*

Under Section 202(e), DOE is required to authorize exports of electricity unless it finds that the proposed transmission "would impair the sufficiency of electric supply within the United States or would impede or tend to impede the coordination in the public interest of facilities. Exports of electricity from the United States to a foreign country are regulated by FERC pursuant to sections 301(b) and 402(f) of the Department of Energy Organization Act (42 U.S.C. 7151(b), 7172(f)) and require authorization under section 202(e) of the FPA.

NATURAL GAS ACT, SECTIONS 3 AND 7
15 U.S.C. § 717 et seq.

DOE has authority under Section 3 to issue orders, upon application, to authorize imports and exports of natural gas. Section 3 requires DOE to approve, without modification or delay, applications to import LNG and applications to import and export natural gas from and to countries with which there is a free-trade agreement in effect requiring national treatment for trade in natural gas.

Under Section 3 of the Natural Gas Act, Executive Order 10485, as amended by Executive Order 12038, and Sections 301(b), 402(e), and (f) of the Department of Energy Organization Act (42 U.S.C. § 7101 et seq.), the Secretary has delegated to FERC authority over the construction, operation, and siting of particular facilities, and with respect to natural gas, that involves the construction of new domestic facilities, the place of entry for imports or exit for exports. FERC also has authority to approve or deny an application for the siting, construction, expansion, and operation of an LNG terminal under Section 3 of the Natural Gas Act.

Section 7 provides FERC the authority to approve the siting of and abandonment of interstate natural gas facilities, including pipelines, storage, and LNG facilities. FERC authority under the Natural Gas Act is to review and evaluate certificate applications for facilities to transport, exchange, or store natural gas; acquire, construct, and operate facilities for such service; and to extend or abandon such facilities. In this context, FERC approvals include the siting of said facilities and evaluation of alternative locations. FERC jurisdiction does not include production, gathering, or distribution facilities, or those strictly for intrastate service.

NATURAL GAS POLICY ACT OF 1978 (NGPA), TITLE III, SECTIONS 301-303
Pub. Law 95-621, 15 U.S.C. § 717 et seq.

DOE has delegated authority under section 302 and 303, respectively, to "authorize purchases of natural gas" and to "allocate supplies of natural gas" in interstate commerce, upon a finding by the President under section 301 of an existing or imminent "severe natural gas shortage, endangering the supply of natural gas for high-priority uses."

Under Sections 301-303, DOE may order any interstate pipeline or local distribution company served by an interstate pipeline to allocate natural gas in order to assist in meeting the needs of high-priority consumers during a natural gas emergency.
DOE has delegated authority (Executive Order 12235) under sections 302 and 303,

respectively, of the Natural Gas Policy Act, to authorize purchases of natural gas and to allocate supplies of natural gas in interstate commerce to assist in meeting natural gas requirements for high-priority uses, upon a finding by the President under section 301 of an existing or imminent natural gas supply emergency (15 U.S.C. §§ 3361-3363). The declaration of a natural gas supply emergency is the legal precondition for the emergency purchase and allocation authority in sections 302 and 303, respectively, of the Natural Gas Policy Act.

Although Executive Order 12235 delegates to the Secretary of Energy the emergency purchase and allocation authorities in sections 302 and 303, respectively, the President has not delegated his authority to declare a natural gas supply emergency. Nothing in the Natural Gas Policy Act would preclude such a presidential delegation.

Under section 301 of the Natural Gas Policy Act, the President may declare a natural gas supply emergency if he makes certain findings. The President must find that a severe natural gas shortage, endangering the supply of natural gas for high-priority uses, exists or is imminent in the United States or in any region of the country. Further, the President must find that the exercise of the emergency natural gas purchase authority under section 302 of the Natural Gas Policy Act, of the emergency allocation authority under section 303 of the Natural Gas Policy Act, or of the emergency conversion authority of section 607 of PURPA is reasonably necessary, having exhausted other alternatives to the maximum extent practicable, to assist in meeting natural gas requirements for high-priority uses. The emergency terminates on the date the President finds that a shortage either no longer exists or is not imminent, or 120 days after the date of the emergency declaration, whichever is earlier.

POWERPLANT AND INDUSTRIAL FUEL USE ACT OF 1978
42 U.S.C. §§ 8301-8484

The President has authority under section 404(a) to allocate coal (and require the transportation of coal) for the use of any power plant or major fuel-burning installation upon a finding of a “severe energy supply interruption,” as defined in section 3(8) of the Energy Policy and Conservation Act 42 U.S.C. § 6202(8). Title II of the Power plant and Industrial Fuel Use Act of 1978 (FUA), as amended (42 U.S.C. 8301 et seq.), provides that no new base load electric power plant may be constructed or operated without the capability to use coal or another alternate fuel as a primary energy source.

In order to meet the requirement of coal capability, the owner or operator of such facilities proposing to use natural gas or petroleum as its primary energy source shall certify, pursuant to FUA section 201(d), and Section 501.60(a) (2) of DOE's regulations to the Secretary of Energy prior to construction, or prior to operation as a base load power plant, that such power plant has the capability to use coal or another alternate fuel. The President may also exercise such allocation authority upon a published finding that a national or regional fuel supply shortage exists or may exist that the President determines is, or is likely to be, of significant scope and duration, and of an emergency nature; causes, or may cause, major adverse impact on public health, safety, welfare or on the economy; and results, or is likely to result, from an interruption in the supply of coal or from sabotage, or from an act of God. Section 404(e) stipulates that the President may not delegate his authority to issue orders under this authority.

FUA section 404(a) authority could be used to help provide coal as an alternative fuel source to electric power plants and other major fuel-burning installations that have received orders prohibiting the burning of natural gas or petroleum as a primary energy source, assuming these facilities actually have the capability to burn coal. This authority also could be used during a coal supply shortage to ensure that coal-burning electric power plants or major fuel-burning installations have adequate supplies of coal.

Those sections of the FUA that restricted the use of natural gas by industrial users and electric generation facilities were repealed in 1987.

ROBERT T. STAFFORD DISASTER RELIEF AND EMERGENCY ASSISTANCE ACT, as amended
42 U.S.C. 5121 et seq.

FEMA, following a presidential declaration of emergency or major disaster, provides assistance and may require other Federal agencies to provide resources and personnel to support State and local emergency and disaster assistance efforts. Requests for a presidential declaration of an emergency or major disaster must be made by the Governor of the affected State based on a finding by the Governor that the situation is of such severity and magnitude that effective response is beyond the capabilities of the State.

DOE supports DHS/FEMA relief efforts by assisting federal, State, and local government and industry with their efforts to restore energy systems in disaster areas. When necessary, DOE also may deploy response staff to disaster sites. DOE is the Sector-Specific Agency for energy and is also is the lead agency directing Emergency Support Function-12 (Energy), which assists the restoration of energy systems and provides an initial point-of-contact for the activation and deployment of DOE resources. These activities are performed pursuant to the Stafford Act, HSPD-5 (Management of Domestic Incidents), and the National Response Framework.

EXECUTIVE ORDER 12656 - *Assignment of Emergency Preparedness Responsibilities*

Part 1,
"Sec. 105. *Interagency Coordination.*
(a) All appropriate Cabinet members and agency heads shall be consulted regarding national security emergency preparedness programs and policy issues. Each department and agency shall support interagency coordination to improve preparedness and response to a national security emergency and shall develop and maintain decentralized capabilities wherever feasible and appropriate.
(b) Each Federal department and agency shall work within the framework established by, and cooperate with those organizations assigned responsibility in, Executive Order No. 12472, to ensure adequate national security emergency preparedness telecommunications in support of the functions and activities addressed by this Order."

"Part 2--General Provisions
Sec. 201. General. The head of each Federal department and agency, as appropriate, shall:
(1) Be prepared to respond adequately to all national security emergencies, including those that are international in scope, and those that may occur within any region of the Nation;
(2)) Consider national security emergency preparedness factors in the conduct of his or her regular functions, particularly those functions essential in time of emergency. Emergency plans and programs, and an appropriate state of readiness, including organizational infrastructure, shall be developed as an integral part of the continuing activities of each Federal department and agency;
(3) Appoint a senior policy official as Emergency Coordinator, responsible for developing and maintaining a multi-year, national security emergency preparedness plan for the department or agency to include objectives, programs, and budgetary requirements;
(4) Design preparedness measures to permit a rapid and effective transition from routine to emergency operations, and to make effective use of the period following initial indication of a probable national security emergency. This will include:
(a) Development of a system of emergency actions that defines alternatives, processes, and issues to be considered during various stages of national security emergencies;
(b) Identification of actions that could be taken in the early stages of a national security emergency or pending national security emergency to mitigate the impact of or reduce significantly the lead times associated with full emergency action implementation;
(5) Base national security emergency preparedness measures on the use of existing authorities, organizations, resources, and systems to the maximum extent practicable;

(6) Identify areas where additional legal authorities may be needed to assist management and, consistent with applicable Executive orders, take appropriate measures toward acquiring those authorities;
(7) Make policy recommendations to the National Security Council regarding national security emergency preparedness activities and functions of the Federal Government;
(8) Coordinate with State and local government agencies and other organizations, including private sector organizations, when appropriate. Federal plans should include appropriate involvement of and reliance upon private sector organizations in the response to national security emergencies;
(9) Assist State, local, and private sector entities in developing plans for mitigating the effects of national security emergencies and for providing services that are essential to a national response;
(10) Cooperate, to the extent appropriate, in compiling, evaluating, and exchanging relevant data related to all aspects of national security emergency preparedness;
(11) Develop programs regarding congressional relations and public information that could be used during national security emergencies; 5
(12) Ensure a capability to provide, during a national security emergency, information concerning Acts of Congress, presidential proclamations, Executive orders, regulations, and notices of other actions to the Archivist of the United States, for publication in the Federal Register, or to each agency designated to maintain the Federal Register in an emergency;
(13) Develop and conduct training and education programs that incorporate emergency preparedness and civil defense information necessary to ensure an effective national response;
(14) Ensure that plans consider the consequences for essential services provided by State and local governments, and by the private sector, if the flow of Federal funds is disrupted;
(15) Consult and coordinate with the Director of the Federal Emergency Management Agency to ensure that those activities and plans are consistent with current National Security Council guidelines and policies.

Sec. 202. Continuity of Government. The head of each Federal department and agency shall ensure the continuity of essential functions in any national security emergency by providing for: succession to office and emergency delegation of authority in accordance with applicable law; safekeeping of essential resources, facilities, and records; and establishment of emergency operating capabilities.

Sec. 203. Resource Management. The head of each Federal department and agency, as appropriate within assigned areas of responsibility, shall:

(1) Develop plans and programs to mobilize personnel (including reservist programs), equipment, facilities, and other resources;
(2) Assess essential emergency requirements and plan for the possible use of alternative resources to meet essential demands during and following national security emergencies;
(3) Prepare plans and procedures to share between and among the responsible agencies resources such as energy, equipment, food, land, materials, minerals, services, supplies, transportation, water, and workforce needed to carry out assigned responsibilities and other essential functions, and cooperate with other agencies in developing programs to ensure availability of such resources in a national security emergency;
(4) Develop plans to set priorities and allocate resources among civilian and military claimants;
(5) Identify occupations and skills for which there may be a critical need in the event of a national security emergency.

Sec. 204. Protection of Essential Resources and Facilities. The head of each Federal department and agency, within assigned areas of responsibility, shall:
(1) Identify facilities and resources, both government and private, essential to the national defense and national welfare, and assess their vulnerabilities and develop strategies, plans, and programs to provide for the security of such facilities and resources, and to avoid or minimize disruptions of essential services during any national security emergency;
(2) Participate in interagency activities to assess the relative importance of various facilities and resources to essential military and civilian needs and to integrate preparedness and response strategies and procedures;
(3) Maintain a capability to assess promptly the effect of attack and other disruptions during national security emergencies.

Sec. 205. Federal Benefit, Insurance, and Loan Programs. The head of each Federal department and agency that administers a loan, insurance, or benefit program that relies upon the Federal Government payment system shall coordinate with the Secretary of the Treasury in developing plans for the continuation or restoration, to the extent feasible, of such programs in national security emergencies."

Sec. 206. Research. The Director of the Office of Science and Technology Policy and the heads of Federal departments and agencies having significant research and development programs shall advise the National Security Council of scientific and technological developments that should be considered in national security emergency preparedness planning."

"Part 7--Department of Energy
Sec. 701. Lead Responsibilities. In addition to the applicable responsibilities covered in Parts 1 and 2, the Secretary of Energy shall:
(1)) Conduct national security emergency preparedness planning, including capabilities development, and administer operational programs for all energy resources, including:
(a) Providing information, in cooperation with Federal, State, and energy industry officials, on energy supply and demand conditions and on the requirements for and the availability of materials and services critical to energy supply systems;
(b) In coordination with appropriate departments and agencies and in consultation with the energy industry, develop implementation plans and operational systems for priorities and allocation of all energy resource requirements for national defense and essential civilian needs to assure national security emergency preparedness;
(c) Developing, in consultation with the Board of Directors of the Tennessee Valley Authority, plans necessary for the integration of its power system into the national supply system;
(2) Identify energy facilities essential to the mobilization, deployment, and sustainment of resources to support the national security and national welfare, and develop energy supply and demand strategies to ensure continued provision of minimum essential services in national security emergencies;
(3) In coordination with the Secretary of Defense, ensure continuity of nuclear weapons production consistent with national security requirements;
(4) Assure the security of nuclear materials, nuclear weapons, or devices in the custody of the Department of Energy, as well as the security of all other Department of Energy programs and facilities;
(5) In consultation with the Secretaries of State and Defense and the Director of the Federal Emergency Management Agency, conduct appropriate international liaison activities pertaining to matters within the jurisdiction of the Department of Energy;
(6) In consultation with the Secretaries of State and Defense, the Director of the Federal Emergency Management Agency, the Members of the Nuclear Regulatory Commission, and others, as required, develop plans and capabilities for identification, analysis, damage assessment, and mitigation of hazards from nuclear weapons, materials, and devices;
(7)) Coordinate with the Secretary of Transportation in the planning and management of transportation resources involved in the bulk movement of energy;
(8) At the request of or with the concurrence of the Nuclear Regulatory Commission and in consultation with the Secretary of Defense, recapture special nuclear materials from Nuclear Regulatory Commission licensees where necessary to assure the use, preservation, or safeguarding of such material for the common defense and security;
(9) Develop national security emergency operational procedures for the control,

utilization, acquisition, leasing, assignment, and priority of occupancy of real property within the jurisdiction of the Department of Energy;
(10) Manage all emergency planning and response activities pertaining to Department of Energy nuclear facilities.

"Sec. 702. Support Responsibilities.
The Secretary of Energy shall:
(1) Provide advice and assistance, in coordination with appropriate agencies, to Federal, State, and local officials and private sector organizations to assess the radiological impact associated with national security emergencies;
(2)) Coordinate with the Secretaries of Defense and the Interior regarding the operation of hydroelectric projects to assure maximum energy output;
(3)) Support the Secretary of Housing and Urban Development and the heads of other agencies, as appropriate, in the development of plans to restore community facilities;
(4)) Coordinate with the Secretary of Agriculture regarding the emergency preparedness of the rural electric supply systems throughout the Nation and the assignment of emergency preparedness responsibilities to the Rural Electrification Administration."

HOMELAND SECURITY PRESIDENTIAL DIRECTIVE 5 (HSPD-5) - Management of Domestic Incidents

This directive enhances the ability of the United States to manage domestic incidents by establishing a single, comprehensive National Incident Management System. It requires all Federal departments and agencies to cooperate with the Secretary of Homeland Security by providing their full and prompt cooperation, resources, and support, as appropriate and consistent with their own responsibilities for protecting the Nation's security. The directive provides direction for Federal assistance to State and local authorities when their resources are overwhelmed, or when Federal interests are involved.

"(1) To enhance the ability of the United States to manage domestic incidents by establishing a single, comprehensive national incident management system."
"(3) To prevent, prepare for, respond to, and recover from terrorist attacks, major disasters, and other emergencies, the United States Government shall establish a single, comprehensive approach to domestic incident management. The objective of the United States Government is to ensure that all levels of government across the Nation have the capability to work efficiently and effectively together, using a national approach to domestic incident management. In these efforts, with regard to domestic incidents, the

United States Government treats crisis management and consequence management as a single, integrated function, rather than as two separate functions."
"(18) The heads of Federal departments and agencies shall adopt the National Incident Management System (NIMS) within their departments and agencies and shall provide support and assistance to the Secretary in the development and maintenance of the NIMS. All Federal departments and agencies will use the NIMS in their domestic incident management and emergency prevention, preparedness, response, recovery, and mitigation activities, as well as those actions taken in support of State or local entities. The heads of Federal departments and agencies shall participate in the National Response Plan (NRP), shall assist and support the Secretary in the development and maintenance of the NRP, and shall participate in and use domestic incident reporting systems and protocols established by the Secretary."*
*The revised National Response Plan became the National Response Framework in 2008 under the Post-Katrina Emergency Management Reform Act.

PRESIDENTIAL POLICY DIRECTIVE 8 (PPD-8) - *National Preparedness*

Presidential Policy Directive 8 (PPD-8) – National Preparedness, replaces the prior national preparedness directive, Homeland Security Presidential Directive – 8 (HSPD-8) issued in 2003, and HSPD-8 Annex I - National Planning, issued in 2007.

PPD-8 takes an all of nation/whole of community capabilities-based approach to preparing for the wide range of threats and hazards the Nation faces. It involves federal partners, state, local, tribal and insular area leaders, the private sector, non-governmental organizations, faith-based and community organizations and the general public.

PPD-8 is comprised of the following:

- *National Preparedness Goal*, the cornerstone for implementation of PPD-8, it identifies the Nation's core capabilities in order to achieve the goal of a secure and resilient Nation;
- *National Preparedness System*, an integrated set of guidance, programs, and processes to enable the Nation to meet the National Preparedness Goal;
- *National Preparedness Report*, an annual summary of the progress being made toward building, sustaining, and delivering the core capabilities described in the Goal;
- *National Planning Frameworks,* coordinating structures that align key roles and responsibilities to deliver the necessary capabilities across each of the five mission areas— Prevention, Protection, Mitigation, Response, and Recovery; and
- *Federal Interagency Operational Plans*, guides that address the critical tasks, responsibilities and resourcing, personnel, and sourcing requirements for the core

capabilities.

With the implementation of PPD-8, the National Response Framework (NRF) will no longer stand alone, but functions as one of five national planning frameworks, each focusing on a different yet interdependent mission area; Prevention, Protection, Mitigation, Response, and Recovery. The revised NRF also focuses on how the Nation delivers these response core capabilities across the whole community, emphasizing the need for the involvement and integration of the whole community.

PRESIDENTIAL POLICY DIRECTIVE 21 (PPD-21) — CRITICAL INFRASTRUCTURE SECURITY AND RESILIENCE

Issued on February 12, 2013, Presidential Policy Directive 21 (PPD-21) — Critical Infrastructure Security and Resilience "…establishes national policy on critical infrastructure security and resilience" as a "shared responsibility among the Federal, state, local, tribal, and territorial (SLTT) entities, and public and private owners and operators of critical infrastructure" and "refines and clarifies the critical infrastructure-related functions, roles, and responsibilities across the Federal Government, as well as enhances overall coordination and collaboration."

PPD-21 has three strategic imperatives:

"1) Refine and clarify functional relationships across the Federal Government to advance the national unity of effort to strengthen critical infrastructure security and resilience;

2) Enable effective information exchange by identifying baseline data and systems requirements for the Federal Government; and

3) Implement an integration and analysis function to inform planning and operations decisions regarding critical infrastructure."

"All Federal department and agency heads are responsible for the identification, prioritization, assessment, remediation, and security of their respective internal critical infrastructure that supports primary mission essential functions. Such infrastructure shall be addressed in the plans and execution of the requirements in the National Continuity Policy."

<u>Roles and Responsibilities</u>

"Effective implementation of this directive requires a national unity of effort pursuant to strategic guidance from the Secretary of Homeland Security. That national effort must include expertise and day-to-day engagement from the Sector-Specific Agencies (SSAs) as well as the specialized or support capabilities from other Federal departments and agencies, and strong collaboration with critical infrastructure owners and operators and SLTT entities. Although the roles and responsibilities identified in this directive are directed at Federal departments and agencies, effective partnerships with critical infrastructure owners and operators and SLTT entities are imperative to strengthen the security and resilience of the Nation's critical infrastructure."

Sector-Specific Agencies

Recognizing existing statutory or regulatory authorities of specific Federal departments and agencies, and leveraging existing sector familiarity and relationships, SSAs shall carry out the following roles and responsibilities for their respective sectors:"
"1)" … "coordinate with the Department of Homeland Security (DHS) and other relevant Federal departments and agencies and collaborate with critical infrastructure owners and operators, where appropriate with independent regulatory agencies, and with SLTT entities, as appropriate";
2) Serve as a day-to-day Federal interface for the dynamic prioritization and coordination of sector-specific activities;
3) Carry out incident management responsibilities consistent with statutory authority and other appropriate policies, directives, or regulations;
4) Provide, support, or facilitate technical assistance and consultations for that sector to identify vulnerabilities and help mitigate incidents, as appropriate; and
5) Support the Secretary of Homeland Security's statutorily required reporting requirements by providing on ann u a l basis sector-specific critical infrastructure information."
"7) The Nuclear Regulatory Commission (NRC) is to oversee its licensees' protection of commercial nuclear power reactors and non-power nuclear reactors used for research, testing, and training; nuclear materials in medical, industrial, and academic settings, and facilities that fabricate nuclear fuel; and the transportation, storage, and disposal of nuclear materials and waste. The NRC is to collaborate, to the extent possible, with DHS, DOJ, the Department of Energy, the Environmental Protection Agency, and other Federal departments and agencies, as appropriate, on strengthening critical infrastructure security and resilience."
"9) Federal departments and agencies shall provide timely information to the Secretary of Homeland Security and the national critical infrastructure centers necessary to support cross-sector analysis and inform the situational awareness capability for critical infrastructure."

Three Strategic Imperatives

1) Refine and Clarify Functional Relationships across the Federal Government to Advance the National Unity of Effort to Strengthen Critical Infrastructure Security and Resilience

"As part of this refined structure, there shall be two national critical infrastructure centers operated by DHS – one for physical infrastructure and another for cyber infrastructure. They shall function in an integrated manner and serve as focal points for critical infrastructure partners to obtain situational awareness and integrated, actionable information to protect the physical and cyber aspects of critical infrastructure." and "integration and analysis function (further developed in Strategic Imperative 3) shall be implemented between these two national centers."
"The success of these national centers, including the integration and analysis function, is dependent on the quality and timeliness of the information and intelligence they receive from the SSAs and other Federal departments and agencies, as well as from critical infrastructure owners and operators and SLTT entities." "These national centers shall not impede the ability of the heads of Federal departments and agencies to carry out or perform their responsibilities for national defense, criminal, counterintelligence, counterterrorism, or investigative activities."

2) <u>Enable Efficient Information Exchange by Identifying Baseline Data and Systems Requirements for the Federal Government</u>

"A secure, functioning, and resilient critical infrastructure requires the efficient exchange of information, including intelligence, between all levels of governments and critical infrastructure owners and operators. This must facilitate the timely exchange of threat and vulnerability information as well as information that allows for the development of a situational awareness capability during incidents. The goal is to enable efficient information exchange through the identification of requirements for data and information formats and accessibility, system interoperability, and redundant systems and alternate capabilities should there be a disruption in the primary systems."

"Greater information sharing within the government and with the private sector can and must be done while respecting privacy and civil liberties. Federal departments and agencies shall ensure that all existing privacy principles, policies, and procedures are implemented consistent with applicable law and policy and shall include senior agency officials for privacy in their efforts to govern and oversee information sharing properly."

3) <u>Implement an Integration and Analysis Function to Inform Planning and Operational Decisions Regarding Critical Infrastructure"</u>
"The third strategic imperative"…"shall include the capability to collate, assess, and integrate vulnerability and consequence information with threat streams and hazard information to:

a. Aid in prioritizing assets and managing risks to critical infrastructure;
b. Anticipate interdependencies and cascading impacts;
c. Recommend security and resilience measures for critical infrastructure prior to,

during, and after an event or incident; and

d. Support incident management and restoration efforts related to critical infrastructure."

"This function shall not replicate the analysis function of the IC or the National Counterterrorism Center, nor shall it involve intelligence collection activities. The IC, DOD, DOJ, DHS, and other Federal departments and agencies with relevant intelligence or information shall, however, inform this integration and analysis capability regarding the Nation's critical infrastructure by providing relevant, timely, and appropriate information to the national centers. This function shall also use information and intelligence provided by other critical infrastructure partners, including SLTT and nongovernmental analytic entities."

Innovation and Research and Development

The Secretary of Homeland Security, in coordination with the Office of Science and Technology Policy (OSTP), the SSAs, DOC, and other Federal departments and agencies, shall provide input to align those Federal and Federally-funded research and development (R&D) activities that seek to strengthen the security and resilience of the Nation's critical infrastructure, including:

1) Promoting R&D to enable the secure and resilient design and construction of critical infrastructure and more secure accompanying cyber technology;
2) Enhancing modeling capabilities to determine potential impacts on critical infrastructure of an incident or threat scenario, as well as cascading effects on other sectors;
3) Facilitating initiatives to incentivize cybersecurity investments and the adoption of critical infrastructure design features that strengthen all-hazards security and resilience; and
4) Prioritizing efforts to support the strategic guidance issued by the Secretary of Homeland Security."

Implementation of the Directive

The Secretary of Homeland Security shall take the following actions as part of the implementation of this directive.

1) Critical Infrastructure Security and Resilience Functional Relationships. Within 120 days of the date of this directive, the Secretary of Homeland Security shall develop a description of the functional relationships within DHS and across the Federal Government related to critical infrastructure security and resilience. It should include the roles and functions of the two national critical infrastructure centers and a discussion of the analysis and integration function." "The Secretary shall coordinate this effort with the SSAs and other relevant Federal departments and agencies. The Secretary shall provide the description to the

President through the Assistant to the President for Homeland Security and Counterterrorism."

"2) Evaluation of the Existing Public-Private Partnership Model. Within 150 days of the date of this directive, the Secretary of Homeland Security, in coordination with the SSAs, other relevant Federal departments and agencies, SLTT entities, and critical infrastructure owners and operators, shall conduct an analysis of the existing public-private partnership model and recommend options for improving the effectiveness of the partnership in both the physical and cyber space."

"3) Identification of Baseline Data and Systems Requirements for the Federal Government to Enable Efficient Information Exchange. Within 180 days of the date of this directive, the Secretary of Homeland Security, in coordination with the SSAs and other Federal departments and agencies, shall convene a team of experts to identify baseline data and systems requirements to enable the efficient exchange of information and intelligence relevant to strengthening the security and resilience of critical infrastructure. "

"4) Update to National Infrastructure Protection Plan. Within 240 days of the date of this directive, the Secretary of Homeland Security shall provide to the President," "a successor to the National Infrastructure Protection Plan to address the implementation of this directive"… "The Secretary shall coordinate this effort with the SSAs, other relevant Federal departments and agencies, SLTT entities, and critical infrastructure owners and operators."

"5) National Critical Infrastructure Security and Resilience R&D Plan. Within 2 years of the date of this directive, the Secretary of Homeland Security, in coordination with the OSTP, the SSAs, DOC, and other Federal departments and agencies, shall provide to the President"

Designated Critical Infrastructure Sectors and Sector-Specific Agencies

"This directive identifies 16 critical infrastructure sectors and designates associated Federal SSAs. In some cases co-SSAs are designated where those departments share the roles and responsibilities of the SSA."

…" Energy:
Sector-Specific Agency: Department of Energy"

EXECUTIVE ORDER 13636 — IMPROVING CRITICAL INFRASTRUCTURE CYBERSECURITY

Released on February 12, 2013, the Executive Order outlines U.S. policy "to enhance the security and resilience of the Nation's critical infrastructure and to maintain a cyber-environment that encourages efficiency, innovation, and economic prosperity while promoting safety, security, business confidentiality, privacy, and civil liberties". The goals can be achieved "through a partnership with the owners and operators of critical infrastructure to improve cybersecurity information sharing and collaboratively develop and implement risk- based standards."

"Sec 4.

(c) To assist the owners and operators of critical infrastructure in protecting their systems from unauthorized access, exploitation, or harm, the Secretary" (of Homeland Security) "in collaboration with the Secretary of Defense, shall, within 120 days of the date of this order, establish procedures to expand the Enhanced Cybersecurity Services program to all critical infrastructure sectors." "This voluntary information sharing program will provide classified cyber threat and technical information from the Government to eligible critical infrastructure companies or commercial service providers that offer security services to critical infrastructure."

(d) The Secretary"…"shall expedite the processing of security clearances to appropriate personnel employed by critical infrastructure owners and operators, prioritizing the critical infrastructure identified in section 9 of this order."

"Sec. 5. Privacy and Civil Liberties Protections. (a) Agencies shall coordinate their activities under this order with their senior agency officials for privacy and civil liberties and ensure that privacy and civil liberties protections are incorporated into such activities. Such protections shall be based upon the Fair Information Practice Principles and other privacy and civil liberties policies, principles, and frameworks as they apply to each agency's activities."

"(b)… The Chief Privacy Officer and the Officer for Civil Rights and Civil Liberties of the Department of Homeland Security (DHS) shall assess the privacy and civil liberties risks of the functions and programs undertaken by DHS"…. "Senior agency privacy and civil liberties officials for other agencies engaged in activities under this order shall conduct assessments of their agency activities and provide those assessments to DHS for consideration and inclusion in the report." "The report shall be reviewed on an annual basis and revised as necessary. The report may contain a classified annex if necessary."

"Sec. 6. Consultative Process. The Secretary shall establish a consultative process to coordinate improvements to the cybersecurity of critical infrastructure. As part of the consultative process, the Secretary shall engage and consider the advice, on matters set forth in this order, of the Critical Infrastructure Partnership Advisory Council; Sector Coordinating Councils; critical infrastructure owners and operators; Sector-Specific Agencies; other relevant agencies; independent regulatory agencies; State, local, territorial, and tribal governments; universities; and outside experts."

"Sec. 7. Baseline Framework to Reduce Cyber Risk to Critical Infrastructure.

(a) The Secretary of Commerce shall direct the Director of the National Institute of Standards and Technology (the "Director") to lead the development of a framework to reduce cyber risks to critical infrastructure (the "Cybersecurity Framework")."

"…(d) In developing the Cybersecurity Framework, the Director shall engage in an open public review and comment process. The Director shall also consult with the Secretary, the National Security Agency, Sector- Specific Agencies and other interested agencies including OMB, owners and operators of critical infrastructure, and other stakeholders through the consultative process established in section 6 of this order."

"Sec. 8. Voluntary Critical Infrastructure Cybersecurity Program.

(a) The Secretary, in coordination with Sector- Specific Agencies, shall establish a voluntary program to support the adoption of the Cybersecurity Framework by owners and operators of critical infrastructure and any other interested entities (the "Program").

(b) Sector-Specific Agencies, in consultation with the Secretary and other interested agencies, shall coordinate with the Sector Coordinating Councils to review the Cybersecurity Framework and, if necessary, develop implementation guidance or supplemental materials to address sector-specific risks and operating environments.

(c) Sector-Specific Agencies shall report annually to the President, through the Secretary, on the extent to which owners and operators notified under section 9 of this order are participating in the Program."

"Sec. 9. Identification of Critical Infrastructure at Greatest Risk.

(a) Within 150 days of the date of this order, the Secretary shall use a risk-based approach to identify critical infrastructure where a cybersecurity incident could reasonably result in catastrophic regional or national effects on public health or safety, economic security, or national security. In identifying critical infrastructure for this purpose, the Secretary shall use the consultative process established in section 6 of this order and draw upon the expertise of Sector-Specific Agencies."

"(b) Heads of Sector-Specific Agencies and other relevant agencies shall provide the Secretary with information necessary to carry out the responsibilities under this section. The Secretary shall develop a process for other relevant stakeholders to submit information to assist in making the identifications required in subsection (a) of this section."

"(c) The Secretary, in coordination with Sector-Specific Agencies, shall confidentially notify owners and operators of critical infrastructure identified under subsection (a) of this section that they have been so identified, and ensure identified owners and operators are provided the basis for the determination."

"(e) Independent regulatory agencies with responsibility for regulating the security of critical infrastructure are encouraged to engage in a consultative process with the Secretary, relevant Sector-Specific Agencies, and other affected parties to consider prioritized actions to mitigate cyber risks for critical infrastructure consistent with their authorities."

NATIONAL SECURITY PRESIDENTIAL DIRECTIVE 51 (NSPD 510 AND HOMELAND SECURITY PRESIDENTIAL DIRECTIVE 20 (HSPD 20) – NATIONAL CONTINUITY POLICY

NSPD 51 and HSPD 20 prescribe continuity requirements for the Executive Branch, organized around National Essential Functions (NEFs). NEFs are government functions necessary to lead and sustain the nation during a catastrophic emergency. Primary Mission Essential Functions (PMEFs) are government functions that must be performed in order to support or implement the performance of NEFs. DOE PMEFs are detailed in the DOE Continuity of Operations Plan. DOE is responsible for the following PMEFs and NEFs:

NATIONAL ESSENTIAL FUNCTIONS (NEF)
NEF # 3: Defending the Constitution of the United States against all enemies, foreign and domestic, and preventing or interdicting attacks against the United States or its people, property, or interests

This NEF includes Federal executive department and agency functions to protect and defend the worldwide interests of the United States against foreign or domestic enemies, honor security agreements and treaties with allies, implement military operations ordered by the President, maintain military readiness, and maintain preparedness to achieve national objectives.

NEF #6: Providing rapid and effective response to and recovery from the domestic consequences of an attack or other incident

This NEF includes Federal executive department and agency functions to implement response and recovery plans, including, but not limited to, the implementation of the National Response Plan

NEF #8: Providing for critical Federal Government services that address the national health, safety, and welfare needs of the United States

This NEF includes Federal executive department and agency functions that ensure that the critical Federal-level health, safety, and welfare services of the Nation are provided during an emergency.

DOE #1: Assure Nuclear Materials Safety: Maintain the safety and security of nuclear materials in the Department of Energy (DOE) Complex at fixed sites and in transit. (NEF#3)

DOE #2: Respond to Nuclear Incidents: Respond to a nuclear incident, both domestically and internationally, caused by terrorist activity, natural disaster or accident, including by mobilizing the resources to support these efforts. (NEF #6)

DOE #3: Manage Energy Infrastructure: Manage the National Energy Infrastructure, the drawdown of Strategic Petroleum Reserve and/or the Northeast Home Heating Oil Reserve. (NEF #6 and #8)

PRIMARY MISSION ESSENTIAL FUNCTION (PMEF) DOE #1

Maintain the safety and security of nuclear materials in the Department of Energy (DOE) Complex at fixed sites and in transit.

Descriptive Narrative: Assure the credibility, viability, reliability and security of U.S. nuclear weapons capability. Assure the prompt availability of technical experience, skills, and capabilities, including from the DOE nuclear weapons complex laboratories, to support essential nuclear weapons work. Assure the safety and security of essential nuclear weapons complex materials, equipment, facilities, and other DOE nuclear materials.

- Securely handle, store, and transfer nuclear materials at all times.
- Validate nuclear materials inventories (accountability).
- Direct and oversee nuclear weapons development, assessment, and certification activities required to maintain the stockpile in a safe and reliable state.
- Support resolution of safety and performance issues associated with the stockpile; ensure the evaluation and assessment of nuclear weapons in the active stockpile to support certification.
- Oversee the qualification of replacement weapon components that are necessary to support essential stockpile requirements.

Implications if Not Conducted: If the Department does not ensure the safety, security, and reliability of nuclear weapons, they may not be readily available when required and nuclear material or weapons could be diverted to unauthorized uses, which could compromise National security. Loss of control or accountability of nuclear materials could also lead to severe economic and/or public health consequences. A by-product of not ensuring security and reliability of the nuclear weapons stockpile is that our nuclear weapons program could lose credibility, thereby eroding National and international confidence in our deterrence capabilities.

Associated National Essential Function (NEF): # 3
Timing: Within 12 hours

Partners: Various State and local law enforcement, Federal Bureau of Investigation (FBI), Department of Defense (DOD), National Laboratories

PRIMARY MISSION ESSENTIAL FUNCTION (PMEF) DOE #2

Respond to a nuclear incident, both domestically and internationally, caused by terrorist activity, natural disaster or accident, including by mobilizing the resources to support these efforts.

Descriptive Narrative: Execute responsibilities under the NRF and other similar plans and agreements. Maintain the capability to immediately notify, alert, mobilize, and deploy radiological emergency response assets, assistance, and/or support on both a domestic and international basis because of emergencies or significant incidents. Provide technical expertise on nuclear and radiological matters and available analytical capabilities of DOE sites and National Laboratories.

- Rapidly respond to emergencies involving nuclear weapons, materials, or facilities, including securing vulnerable foreign nuclear materials.
- Respond to a nuclear incident, both domestically and internationally, resulting from terrorist activity, natural disaster, or accident.
- Nuclear Weapons Incident Response - Nuclear Emergency Support Team provides technical assistance to a lead Federal Agency on various incidents including terrorist's threats involving the use of nuclear materials.
- National Technical Nuclear Forensics Program, which enables operational support for pre- detonation and post-detonation nuclear forensics and attribution program.
- National Weapons Incident Response - Stabilization Implementation Program - leverages and develops "Render Safe" technologies that can be applied by teams to isolate and stabilize a nuclear device until the National response teams arrive to render it safe.

Implications if Not Conducted: If the Department does not respond effectively to emergencies or incidents involving nuclear and radiological materials, the safety and health of citizens would be jeopardized.

Associated National Essential Function (NEF): # 6
Timing: Within 12 hours
Partners: Various State and local law enforcement, Environmental Protection Agency, Department of State (DOS), FBI, Department of Agriculture, DOD, DOE National Laboratories and Field offices, Federal Emergency Management Agency

PRIMARY MISSION ESSENTIAL FUNCTION (PMEF) DOE #3

Primary Mission Essential Function (PMEF) DOE #3: Continuously monitor and manage the National energy infrastructure including the drawdown of Strategic Petroleum Reserve and/or the Northeast Home Heating Oil Reserve. Respond to energy infrastructure disruptions to ensure rapid recovery of energy supplies.

Descriptive Narrative: Monitor and publish information regarding the Nation's Energy Infrastructure including the status of energy facilities and resources (storage, production, and transmission facilities) that support National security and welfare. Manage the Strategic Petroleum Reserve, the Northeast Heating Oil Reserve, and the Federal Power Marketing Administrations. Manage and direct the DOE National Laboratory capabilities to provide necessary technical support to respond to significant energy infrastructure disruptions. Advise National leadership on the allocation of energy resources.
Execute responsibilities under ESF #12 in the National Response Framework. Coordinate National energy related issues:

- Conduct assessments and analyses of impacts to energy storage.
- Conduct assessments of power production, generation, transmission, and distribution.
- Assess the infrastructure and transportation systems related to oil, gas, and coal.
- Collect, evaluate, assemble, analyze, and disseminate data and information related to energy resources, production, demand, technology, and related economic and statistical information.

Implications if Not Conducted: If the Department does not act in response to a wide-scale, energy- related emergency, the energy infrastructure will be forced to attempt matter resolution on a State-by- State or region-by-region basis.

Associated National Essential Functions (NEFs): #6 and 8
Timing: Within 12 hours
Partners: Various States, utilities, private companies, DHS, DOE National Laboratories and program offices, Nuclear Regulatory Commission

APPENDIX E: COMMON INDUSTRY TERMS

Glossary[8]

(Note: For reference purposes)

Access Charge: A fee levied for access to a utility's transmission or distribution system.

Alternating Current (AC): An electric current that reverses its direction of flow periodically, AX is wave of electrons that flow back and forth through a conductor wire.

Ampere (amp): A unit of measuring electric flow

Ancillary Services: Services necessary to support the transmission of electric energy from resource loads, while maintaining reliable operation of the transmission system. Examples include spinning reserve, supplemental reserve, reactive power, regulation and frequency response, and energy imbalance.

Available Transmission Capacity (ATC): A measure of the electric transfer capability remaining in the physical transmission network for sale over and above already committed users.

Biomass: In the contest of electric energy, any organic material that is converted to electricity, including woods, canes, grasses, farm manure, and sewage.

Blackout: Emergency loss of electricity due to fail of generation, transmission, or distribution

Black Start: the process of restoring a power station to operation without relying on the external electric power transmission network.

British Thermal Unit (BTU): A unit of energy equivalent to 1,055 Joules, and is also the energy required to raise 1 pound of water 1 degree Fahrenheit at 39 degrees Fahrenheit.

Bulk Power System: All generating plants, transmission lines and equipment.

Busbar Cost: The cost of producing one KWh of electricity delivered to, but not through the transmission system.

Busbar: The point at which power is available for transmission.

Capacitor: A device that maintains or increases voltage in power lines and improves efficiency of the system by compensating for inductive losses.

Cascading Outage: The uncontrolled, successive loss of system elements triggered by an incident at any location. Results in widespread service interruption that cannot be restrained.

Circuit: A path through which electric current can flow.

Commission: The regulatory body having jurisdiction over a utility.

Congestion: Transmission paths that are constrained, which may limit power transactions because of insufficient capacity. Congestion can be relieved by increasing generation or by reducing load.

[8] Source: energy.gov/sites/prod/files/oeprod/DocumentsandMedia/primer.pdf

Control Area: Electric power system in which operators match loads to resources within the system, maintain scheduled interchange between control areas, maintain frequency within reasonable limits, and provide sufficient generation capacity to maintain operating reserves.

Curtailment: A reduction in the scheduled capacity or energy delivery due to a transmission constraint.

Demand: The amount of power consumers require at a particular time. Demand is synonymous with load. System demand is measured in megawatts (MW).

Demand Response (DR): Deliberate intervention by a utility in the marketplace to influence demand for electric power or shift the demand to different times to capture cost savings.

Direct Current: Electricity flowing continuously in one direction, the constant flow of electrons in a wire.

Dispatch: The physical inclusion of a generator's output onto the transmission grid by an authorized scheduling utility.

Distributed Generation (DG): Electric generation that feeds into the distribution grid, rather than the bulk transmission grid, whether on the utility side of the meter, or on the customer side.

Electrical Energy: The generation or use of electric power over a period, usually expressed in megawatt hours (MWh), kilowatt hours (KWh) or gigawatt hours (GWh), as opposed to electric capacity which is measured in kilowatts.

Federal Energy Regulatory Commission (FERC): A federal agency created in 1977 to regulate, among other things, interstate wholesale sales and transportation of gas and electricity at "just and reasonable" rates.

Firm Transmission Right (FTR): An FTR is a tradable entitlement to schedule 1 megawatt for use of a flow path in a particular direction for a particular hour.

Firm Transmission: Transmission service that may not be interrupted for any reason except during emergency when continued delivery of power is not possible.

Forced Outage: Shutdown of a generating unit, transmission line or other facility for emergency reasons. Forced outage reserves consist of peak generating capability available to serve loads during forced outages.

Frequency: The oscillatory rate in Hertz (Hz-cycles per second) of the alternating current in a circuit. The standard frequency across the bulk power system is 60 Hz in the United States and 50 Hz in Europe. Maintaining standard system frequency of the grid within acceptable limits is the responsibility of the control area operator (CAO).

Grid: Layout of the electrical transmission system; a network of transmission lines and the associated substations and other equipment required to move power.

High Voltage Lines: Used to transmit power between utilities. The definition of "high" varies, but it is opposed to "low" voltage lines that deliver power to homes and most businesses.

Incremental Rates: The allocation of cost for an additional service or construction project directly to those who benefit from the service instead of rolling it into overall rates. To determine the incremental unit cost, the added cost is divided by the added capacity or output (See Rolled-in Pricing).

Independent System Operator (ISO): Entity that controls and administers nondiscriminatory access to electric transmission in a region across several systems, independent from the owners of the facilities.

Interchange (or Transfer): The exchange of electric power between control areas.

Interconnection: A specific connection between one utility and another. NERC's definition: "When capitalized, any one of the four bulk electric system networks in North America: Eastern, Western, ERCOT and Quebec. When not capitalized, the facilities that connect two systems or control areas.

Intertie: Usually refers to very high voltage lines that carry electric power long distances. A term also used to describe a circuit connecting two or more control areas or systems of an electric system ("tie line").

Joule (J): A unit of energy equivalent to 1 Watt of power used over 1 second.

Kilovolt (kV): Electrical potential equal to 1,000 volts.

Kilowatt (kW): A unit to measure the rate at which electric power is being consumed. One kilowatt equals 1,000 watts.

Kilowatt-Hour (kWh): The basic unit for pricing electric energy; equal to 1 kilowatt of power supplied continuously for one hour. (Or the amount of electricity needed to light 10 100-watt light bulbs for one hour.) One kilowatt hour equals 1,000 watt hours.

Line losses: Power lost in the course of transmitting and distributing electricity.

Load: The amount of power demanded by consumers. It is synonymous with demand.

Load Balancing: Meeting fluctuations in demand or matching generation to load to keep the electrical system in balance.

Load Forecast: An attempt to determine energy consumption at a future point in time.

Load Profiling: The process of examining a consumer's energy use in order to gauge the level of power being consumed and at what times during the day.

Load Serving Entity (LES): Any entity providing service to load.

Load Shedding: The process of deliberately removing (either manually or automatically) preselected demands from a power system, in response to an abnormal condition (such as very high load), to maintain the integrity of the system.

Load Shifting: Shifting load from peak to off-peak periods, including use of storage water heating, storage space heating, cool storage, and customer load shifts.

Locational Marginal Pricing (LMP): Under LMP, the price of energy at any location in a network is equal to the marginal coast of supplying an increment of load at that location.

Loop Flow: The unscheduled use of another utility's transmission, resulting from movement of electricity along multiple paths in a grid, whereby power, in taking path of least resistance, might be physically delivered through any of a number of possible paths that are not easily controlled.

Market Clearing Price: Price determined by the convergence of buyers and sellers in a free market.

Megawatt (MW): One megawatt equals one million kilowatts.

Megawatt-hour (MWh): One megawatt hour is equal to one million kilowatt hours.

Megawatt-mile Rate: An electric transmission rate based on distance, as opposed to postage stamp rates, which are based on zones.

Megawatt-year and megawatt-months: Units to measure and price transmission services. A megawatt-year is 1 megawatt of transmission capacity made available for one year. Similarly, a megawatt-month is 1 megawatt of capacity made available for one month.

Network: A system of transmission or distribution lines cross-connected to permit multiple supplies to enter the system.

Network Transmission (NT): A transmission contract or service as described in a transmission provider's Open Access Transmission Tariff filed with the Federal Energy Regulatory Commission.

Non-firm Transmission: Transmission service that may be interrupted in favor of firm transmission schedules or for other reasons.

North American Electric Reliability Council (NERC): Former in 1968 to promote the reliability of generation and transmission in the electric utility industry. Consists of 10 regional reliability councils and one affiliate encompassing all the electric systems in the United States, Canada, and the northern part of Baja, Mexico.

Ohm (Ω): A unit of electric resistance equivalent to 1 volt per ampere.

Open Transmission Access: Transmission is offered equally to all interested parties

Outage: Removal of generating capacity from service either forced or scheduled. Pancaking: Fees that are tacked on as electricity flows through a number of transmission systems.

Parallel Path Flows: The difference between the scheduled and actual power flow, assuming zero inadvertent interchange, on a given transmission path.

Synonyms: Loop flows, unscheduled power flows, and circulating power flows.

Peak Demand: The maximum (usually hourly) demand of all customer demands plus losses. Usually expressed in MW.

Performance-based Regulation: Rates designed to encourage market responsiveness. They can be automatically adjusted from an initial cost-of-service rate based on a company's performance. Performance indicators generally reflect consumer and societal values.

Point of Delivery: The physical point of connection between the transmission provider and a utility. Power is metered here to determine the cost of the transmission service.

Point-to-Point Transmission Service: The reservation and/or transmission of energy on either a firm basis and/or a non-firm basis from point(s) of receipt to point(s) of delivery under a tariff, including any ancillary services that are provided by the transmission provider.

Postage Stamp Rates: Flat rates charged for transmission service without regard to distance.

Power Pool: Two or more interconnected electric systems planned and operated to supply power in the most reliable and economical manner for their combined load requirements and maintenance programs.

Public Utility Holding Company Act (PUHCA): Legislation enacted in 1935 to protect utility stockholders and consumers from financial and economic abuses of utility holding companies. Generally, ownership of 10 percent or more of the voting securities of a public utility subjects a company to extensive regulation under the Securities and Exchange Commission. The Comprehensive National Energy Policy Act of 1992 opened the power market by granting a class of competitive generators exemption from PUHCA regulation. Radial: An electric transmission or distribution system that is not networked and does not provide sources of power.

Rate Base: The investment value established by a regulatory authority upon which a utility is permitted to earn a specified rate of return.

Reactive Power: The out-of-phase component of the total volt-amperes in an electric circuit, usually expressed in VAR (volt-ampere-reactive). It represents the power involved in the electric fields developed when transmitting alternating-current power (the alternating exchange of stored inductive and capacitive energies in a circuit). Used to control voltage on the transmission network, particularly the power flow incapable of performing real work or energy transfer.

Real Power: Portion of the electrical flow capable of performing real work or energy transfer. Expressed in megawatts.

Real Time Pricing: Time-of-day pricing in which customers receive frequent signals on the cost of consuming electricity at that moment.

Regional Transmission Organization (RTO): An independent regional transmission operator and service provider that meets certain criteria, including those related to independence and market size, established by FERC Order 2000.

Reliability Practices: The methods of implementing policies and standards designed to ensure the adequacy and security of the interconnected electric transmission system in accordance with applicable reliability criteria (i.e., NERC, local regional entity criteria).

Reliability: Term used to describe a utility's ability to deliver an uninterrupted stream of energy to its customers and how well the utility's system can handle an unexpected shock that may affect generation, transmission or distribution service.

Right-of-Way: Strip of land used for utility lines. Most utilities negotiate easements with property owners or use the right of eminent domain to gain access. In some cases, the land is purchased outright.

Rolled-in Pricing: The allocation of cost for an additional service or construction project into overall rates, regardless of the cause or beneficiary of the cost.

Schedule: An agreed-upon transaction size (mega-watts), start and end time, beginning and ending ramp times and rate, and type required for delivery and receipt of power and energy between the contracting parties and the control area(s) involved in the transaction.

Scheduled Outage: Scheduled outages occur when a portion of a power system is shut down intentionally, typically to allow for pre-planned activities such as maintenance.

Seams: The interface between regional entities and/or markets at which material external impacts may occur. The regional entities' actions may have reliability, market interface, and/or commercial impacts (some or all).

Service Territory: Physical area served by a utility.

Spinning Reserve: Electric generating units connected to the system that can automatically respond to frequency deviations and operate when needed.

Spot Market: A market characterized by short-term, typically interruptible or best efforts contracts for specified volumes. The bulk of the natural gas spot market trades on a monthly basis, while power marketers sell spot supplies on an hourly basis.

Standards of Conduct: When FERC established the requirement for companies to use OASIS systems in electric transmission (Order 889), it also established a code of conduct to ensure that transmission owners and their affiliates would not have an unfair competitive advantage in using the transmission lines to sell power.

Standby Demand: The demand specified by contractual arrangement with a customer to provide power and energy to that customer as a secondary source or backup for the outage of the customer's primary source. Standby demand is intended to be used infrequently by any one customer.

Step-Down/Step-Up: Step-down is the process of changing electricity from a higher to a lower voltage. Step-up is the opposite. Step-up transformers usually are located at generator sites, while step-down transformers are found at the distribution side.

Substation: Equipment that switches, steps down, or regulates voltage of electricity. Also serves as a control and transfer point on a transmission system.

Superconductivity, High Temperature (HTS): A technology for transmitting electricity that uses a conductor designed to offer no resistance to electrical voltage. No resistance allows power to be transmitted without losses. Materials typically have no resistance at temperatures approaching absolute zero (-273°C). High temperature, for this purpose, means a temperature high enough to maintain cost-effectively while maintaining superconductivity.

Supervisory Control and Data Acquisition (SCADA): A system of remote control and telemetry used to monitor and control the electric transmission system.

Tariff: A document, approved by the responsible regulatory agency, listing the terms and conditions, including a schedule of prices, under which utility services will be provided.

Total Transmission Capability (TTC): The amount of electric power that can be transferred over the interconnected transmission network in a reliable manner at a given time.

TRANSCO (Transmission Company): A company engaged solely in the transmission function;

another kind of regional transmission organization. A TRANSCO owns and operates the regional transmission system. Also refers to the portion of an electric utility's business that involves bulk transmission of power, operated separately from any other power functions the utility might own or operate.

Transfer Capability: The measure of the ability of interconnected electric systems to move or transfer power in a reliable manner from one area to another over all transmission lines (or paths) between those areas under specified system conditions. Generally expressed in megawatts (MW). In this context, "area" may be an individual electric system, power pool, control area, sub-region or NERC region, or a portion of any of these.

Transformer: Electrical device that changes the voltage in AC circuits.

Transmission Loading Relief (TLR): Procedures developed by NERC to mitigate operating security limit violations.

Transmission Operating Agreement (TOA): An agreement between an RTO and a utility, whereby the utility assigns control over the utility's transmission system in exchange for an RTO agreement to make payment to the utility to cover the utility's transmission system costs.

Transmission Reliability Margin (TRM): Amount of transmission transfer capability necessary to ensure that the interconnected transmission network is secure under a reasonable range of uncertainties in system conditions.

Transmission: The process of transporting wholesale electric energy at high voltages from a supply source to utilities.

Vertical Integration: Refers to the traditional electric utility structure, whereby a company has direct control over its transmission, distribution and generation facilities and can offer a full range of power services.

Volt: The unit of electromotive force or electric pressure which, if steadily applied to a circuit having a resistance of 1 ohm, would produce a current of one ampere.

Voltage-Ampere-Reactive (VAR): The unit of measurement for reactive power. Recall that 1 Watt = 1 Volt-Ampere.

Watt: The electrical unit of real power or rate of doing work, equivalent to 1 ampere flowing against an electrical pressure of 1 volt. One watt is equivalent to about 1/746 horsepower, or 1 joule per second.

Wheeling: In the electric market, "wheeling" refers to the interstate sale of electricity or the transmission of power from one system to another.

Wholesale Competition: A system in which a distributor of power would have the option to buy its power from a variety of power producers, and the power producers would be able to compete to sell their power to a variety of distribution companies.

Wholesale Electricity: Power that is bought and sold among utilities, nonutility generators and other wholesale entities, such as municipalities.

Wholesale Power Market: The purchase and sale of electricity from generators to resellers (that sell to retail customers) along with the ancillary services needed to maintain reliability and power quality at the transmission level.

Wholesale Wheeling: The transmission of electricity from a wholesale supplier to another wholesale supplier by a third party.

Wires Charge: A fee that is imposed on retail power providers or their customers to use a utility's transmission and distribution system.