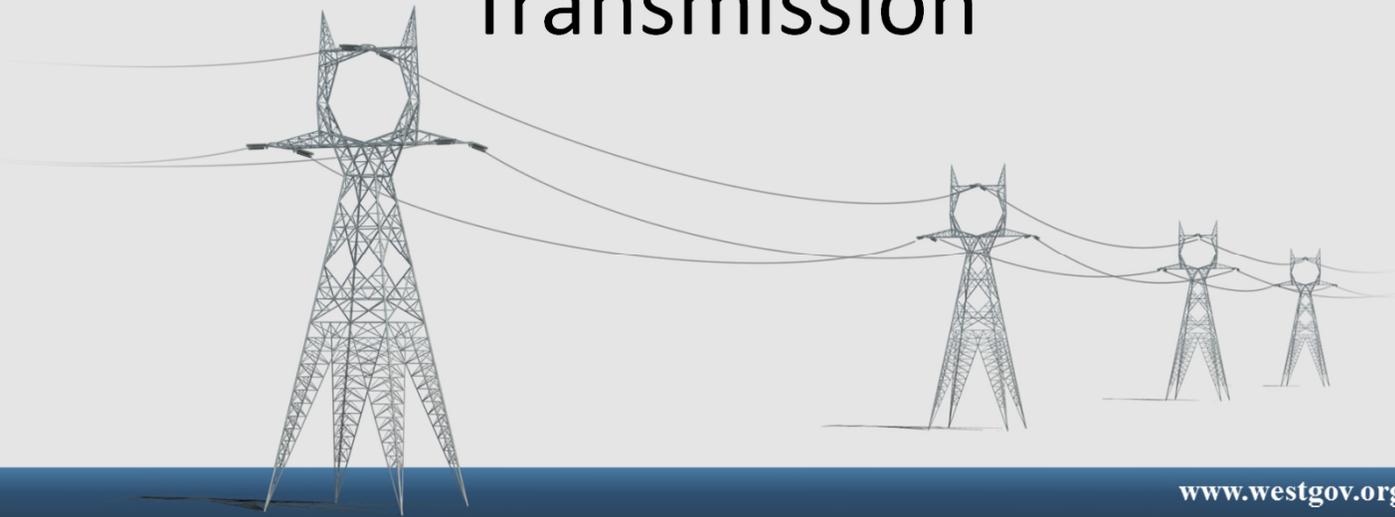




Bangladesh Trustful Firefighting

An Introduction to Electric Power Transmission



An Introduction to Electric Power Transmission – Table of Content (TOC)

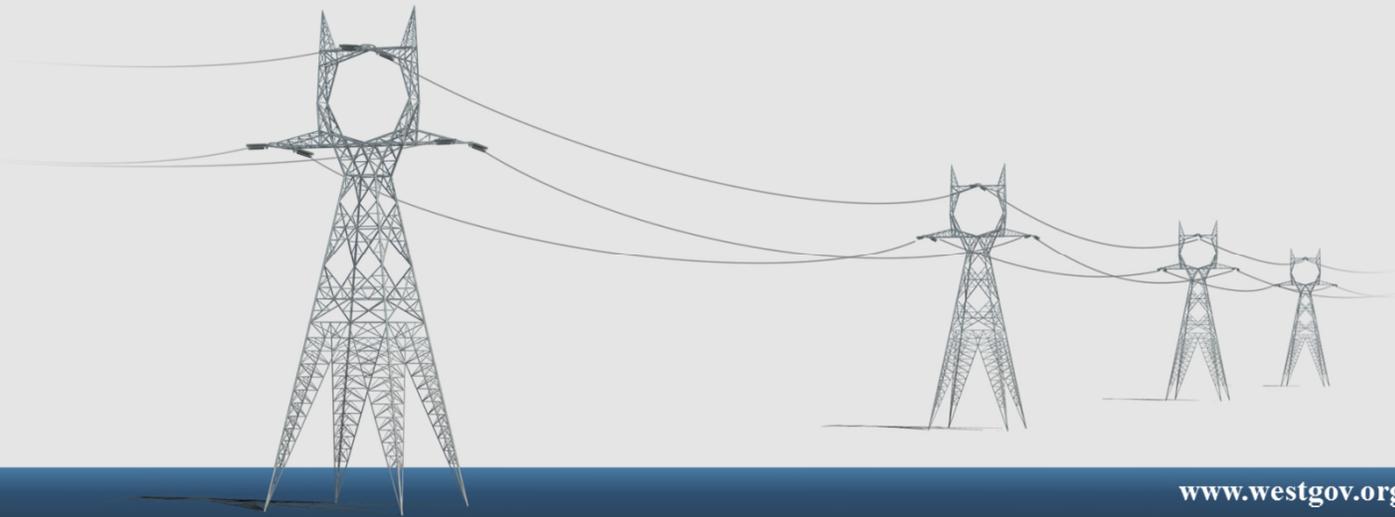
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Bangladesh Trustful Firefighting

Glossary



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Basic Definition/Terminology

- **Alternating Current (AC)** – Electric current in which the direction of the current's flow is reversed or alternated at 60Hz in the U.S.
- **Audible Noise (AN)** – A measure in units of decibels on a logarithmic scale. Because human hearing is not equally sensitive to all frequencies of sound, certain frequencies are given more “weight.” Noise levels capable of being heard by humans are measured in A-weighted decibels (dBA).
- **Conductors (Power Lines)** – Metal cables used for carrying electric current.
- **Corona** – Electrical breakdown of the air near high voltage conductors into charged particles.



Basic Definition/Terminology

- **Current** – The flow of electricity or the movement of electrons through a conductor typically measured in watts.
- **Direct Current (DC)** – Electric current flows continuously in the same direction as contrasted with alternating current.
- **Distribution Line** – A line that carries electricity at lower voltages of 12kV to 44kV and is used to distribute power drawn from high-voltage transmission systems to end-use customers.
- **Electric & Magnetic Fields (EMF)** – Invisible areas of energy, often referred to as radiation, that are associated with the use of electric power. EMFs fall into one of two radioactive categories – non-ionizing (low-level of radiation) or ionizing (high-level of radiation).



Basic Definition/Terminology

- **Electric Load** – Electricity consumers, such as residences, businesses, and government centers that use electricity.
- **Electric Power Transmission** – The process by which large amounts of electricity produced are transported over long distances for eventual use by consumers.
- **Energy** – The amount of work that can be done by electricity, typically measured in kilowatt-hours (kWh) or megawatt-hours (MWh).
- **Foundation** – System that transfers to the ground the various dead and live loads of the transmission structure and conductors.
- **Generation** – The production of electric energy. Fossil fuels, wind turbines, solar panels, and other technologies are used to generate electricity.



Basic Definition/Terminology

- **Insulators** – Used to contain, separate, or support electrical conductors.
- **Interconnection** – Points on a grid or network where two or more transmission lines are connected at a substation or switching station, or where one stage of the energy supply chain meets the next.
- **Load Center** – A particular geographical area where energy is used. Most commonly refers to an area within a utility's service territory where energy demand is highest (i.e., cities, major industrial areas, etc.).
- **National Electrical Safety Code (NESC)** – The NESC is the U.S. standard of the safe installation, operation, and maintenance of electric power systems.



Basic Definition/Terminology

- **Power** – Rate at which electricity does work. Measured in watts or kilowatts (kW) or megawatts (MW).
- **Rights-of-Way (ROW)** – A legal land right, easement, set aside for the transmission line structure and conductors needed for clearances and maintenance activities.
- **Shield and Ground Wire** – Wires used primarily for protection from lightning strikes and corresponding surges.
- **Substation** – A part of an electrical transmission system that transforms voltage from high to low, or the reverse.
- **Switching Station** – A part of an electrical transmission system that ties two or more electric circuits together through switches, to permit a circuit to be disconnected, or to change the electric connection between circuits.



Basic Definition/Terminology

- **Transmission Line** – A line that carries electricity at voltages of 69kV or greater and is used to transmit electric power over relatively long distances, usually from a central generating station to main substations.
- **Transmission Structures** – Used to keep high-voltage conductors (power lines) separated from their surroundings and from each other.
- **Voltage** – Electric “pressure” measured in volts. Power systems are typically measured in 1,000s volts or kV.
- **Watt** – Unit of electrical power. 1MW is one million watts.



About Transmissions Lines

Electricity Generation and Delivery

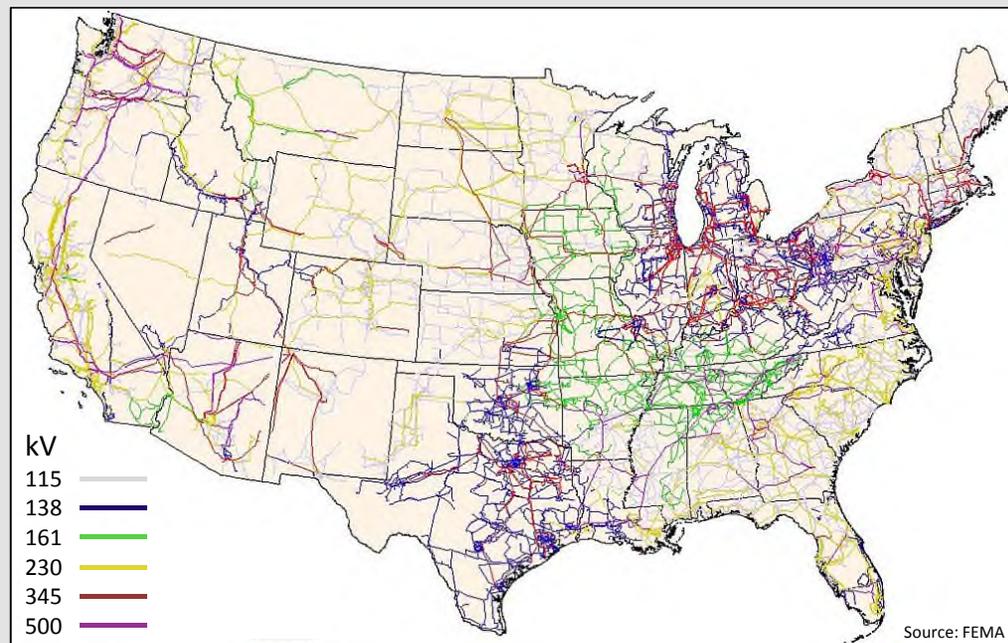


Electricity Generation and Delivery

Electric Operating Systems

The National Electric Grid

- The U.S. electric grid is a complex interconnected system of electric transmission lines linking generators to loads.



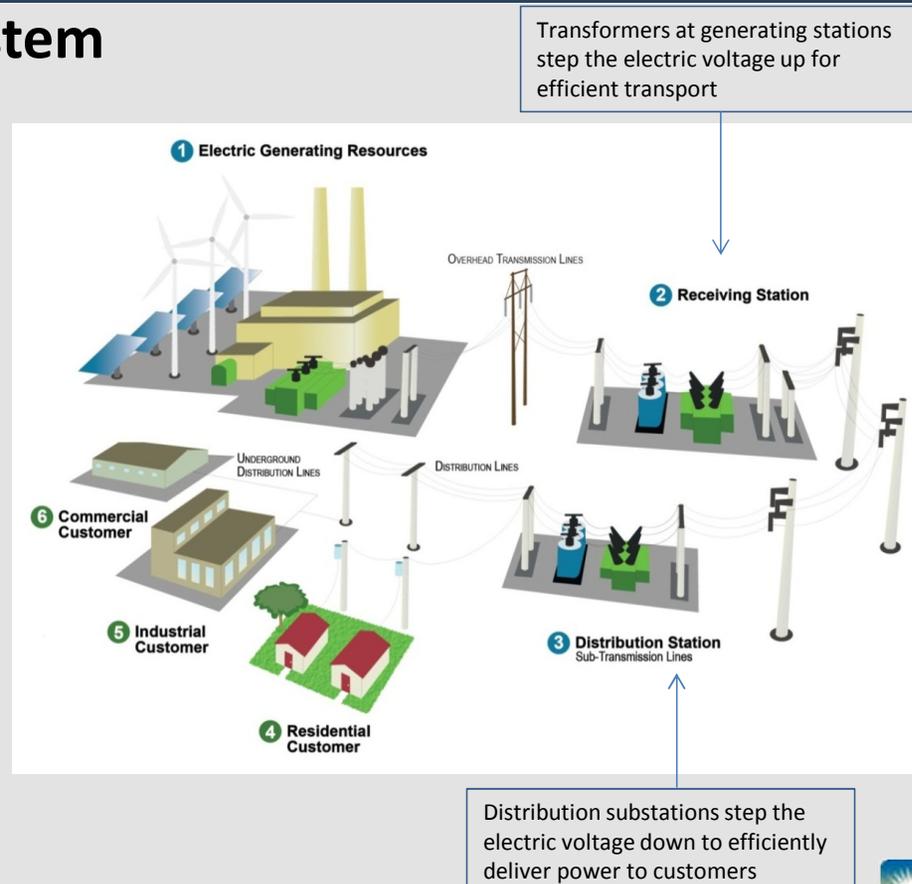
Electricity Generation and Delivery

Electric Operating Systems

The Electric Power System

The diagram depicts the basic elements of an electric power system:

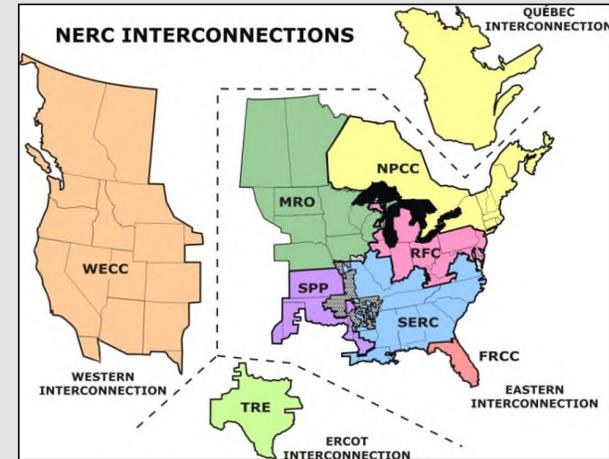
- *Generation* – Where energy is created
- *Transmission and Distribution* – Energy is transported across high-voltage transmission to lower-voltage distribution lines
- *Load* – Power is delivered to homes and businesses



Electricity Generation and Delivery

Interconnections and Reliability

- The national grid is overseen by the Federal Energy Regulatory Commission (FERC) and the North American Electric Reliability Corporation (NERC).
 - 3 Regional Interconnections
 - 8 Regional Entities
 - 8 Independent System Operators (ISO)
 - 4 Regional Transmission Organizations (RTO)
- Entities responsible for reliability of the national grid system:
 - FERC, NERC
 - Regional Entities
 - Utilities
 - Regional Transmission Organizations (RTOs)
 - Independent System Organization (ISOs)

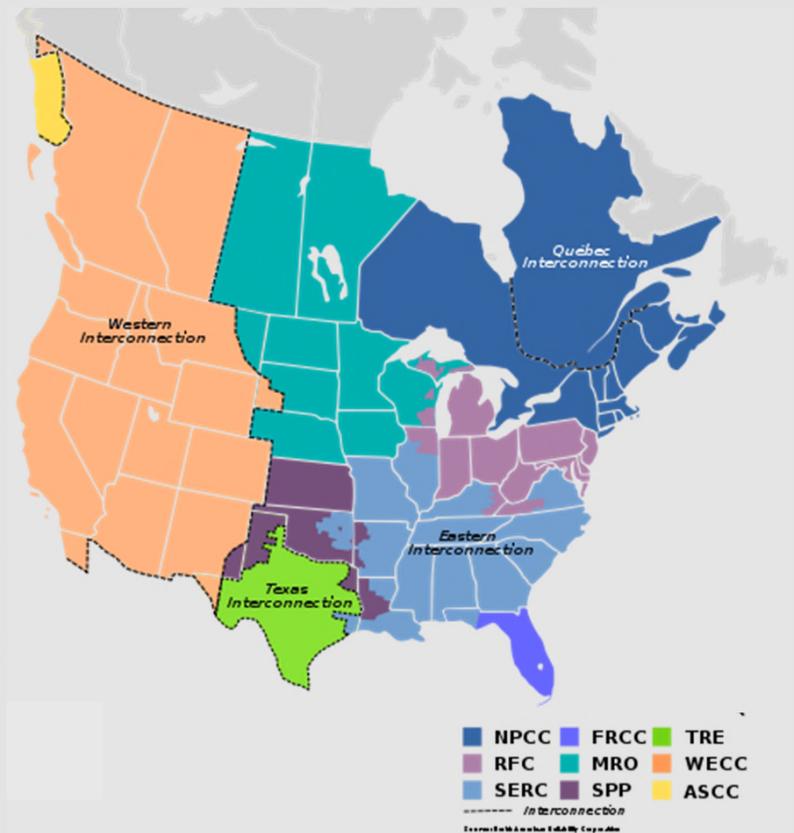


Electricity Generation and Delivery

The Western Grid

Western Interconnect

- Bulk movement of electricity is accomplished within three electrically separate zones:
 - The Western Interconnect
 - The Eastern Interconnect
 - The Texas Interconnect
- The Western Interconnect is composed of 11 states, two Canadian provinces, and northern Mexico.

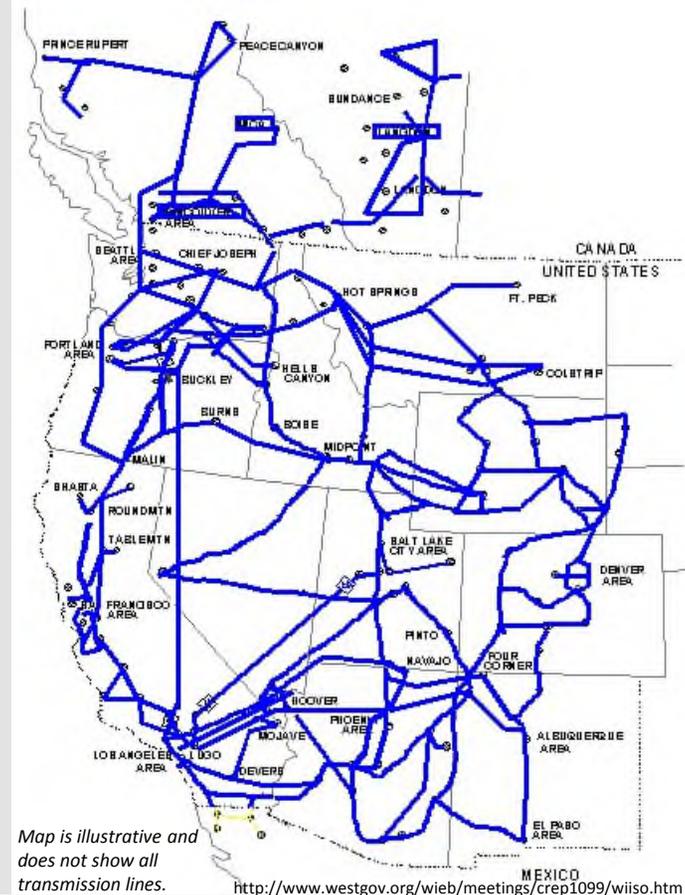


Electricity Generation and Delivery

The Western Grid

Western Interconnect

- Two Federal Power Marketing Agencies (FPMAs)
 - Bonneville Power Administration (BPA)
 - Western Area Power Administration (WAPA)
- Thirty seven balancing authorities (BAs)
- Alternating and Direct Current Resources
- Four Transmission Planning Agencies:
 - Columbia Grid
 - Northern Tier
 - West Connect
 - Cal-ISO

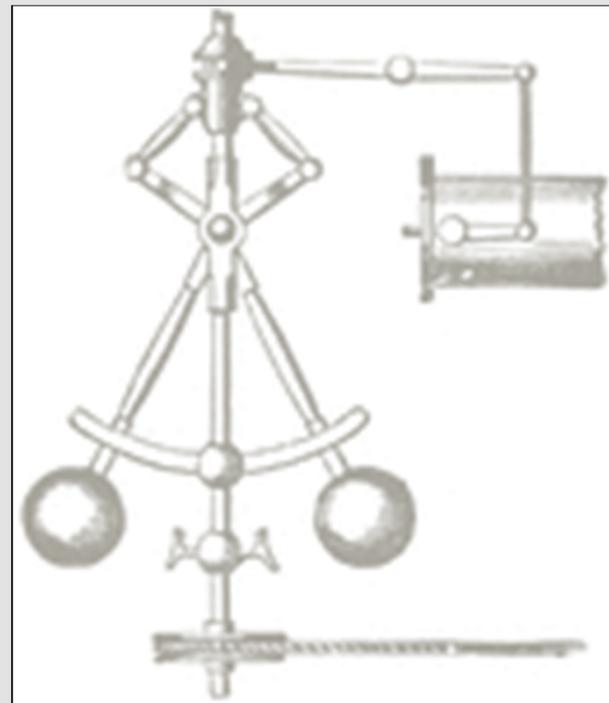


Electricity Generation and Delivery

The Western Grid

Operational Constraints

- As one large machine, the Western Interconnect must be balanced moment to moment (frequency based).
- In other words, energy that is generated must be consumed immediately as there is minimal storage in the system.
- Under or over supply leads to disruptions (blackouts) and those are reliability issues.



Electricity Generation and Delivery

What is meant by reliability?

- For each of the three transmission grids the National Electricity Reliability Corporation (NERC) defines reliability.
 - If your lights came on, reliability was met.
 - If a major line is lost and the system remains stable, reliability was met.
 - If a generation source is lost and the system remains stable, reliability was met.
- It is more complicated in reality, but if it is not met, the provider can be fined.



About Transmissions Lines

Transmission Line Ownership and Funding



Transmission Ownership & Funding

Transmission Ownership/Funding

- **Electric Utility – privately-held company, government agency, publicly owned body, or other entity that meets three specific criteria.**
 - Owns and/or operates facilities for provision of a service directly related to electric energy provision
- **Transmission providers fall into the following categories:**
 1. Investor-owned utilities
 2. Rural cooperatives and public power entities
 3. Public power authorities
 4. Merchant transmission providers



Electricity Generation and Delivery

Transmission Ownership/Funding

- **Investor-owned utility (IOU)** – Utility owned by private investors, as opposed to rural cooperatives or public power entities. An IOU may own both generation and transmission and they can recover the costs of new transmission lines through FERC-approved transmission tariffs and their electricity rates.
- **Rural Cooperatives and Public Power Entities** – A customer-owned electric utility created to transmit and distribute power in rural areas.
 - Rates are typically set by a board of directors elected from among the cooperative's members.
 - Although rates are not regulated by public utility commissions, their facilities are subject to the same state siting requirements as investor-owned utilities.



Electricity Generation and Delivery

Interconnections and Reliability

Transmission Ownership/Funding

- **Public Power Authorities** – Typically owned by a city or municipality.
 - Not-for-profit utility
- **Public Power Utilities** – Owned by a city or municipality
 - The utilities are directly accountable to the people they serve through locally elected or appointed officials.
 - Example: Los Angeles, San Antonio, Seattle, and Orlando operate publicly owned electric utilities
- **Merchant Transmission Providers** – Privately-owned companies that finance and own transmission facilities independent of generation developers or customer-serving utilities.
 - Must take on the financial responsibility and risk associated with building a new transmission line (unlike utilities)
 - Costs are recouped through access charges paid by generators and/or load serving utilities



Electricity Generation and Delivery

Why do we need new transmission?

- Meet regulatory reliability and public policy requirements
 - FERC 1000
 - Public Policy
 - Least Cost
 - Economic
- Meet the growing need for safe, reliable electricity
- Connect new generation sources to the grid
- Improve reliability, efficiency
- Renewable portfolio standards and integrating renewables
- Access additional resources to reduce cost, diversify risk
- Reduce congestion
- Improve economics



About Transmissions Lines

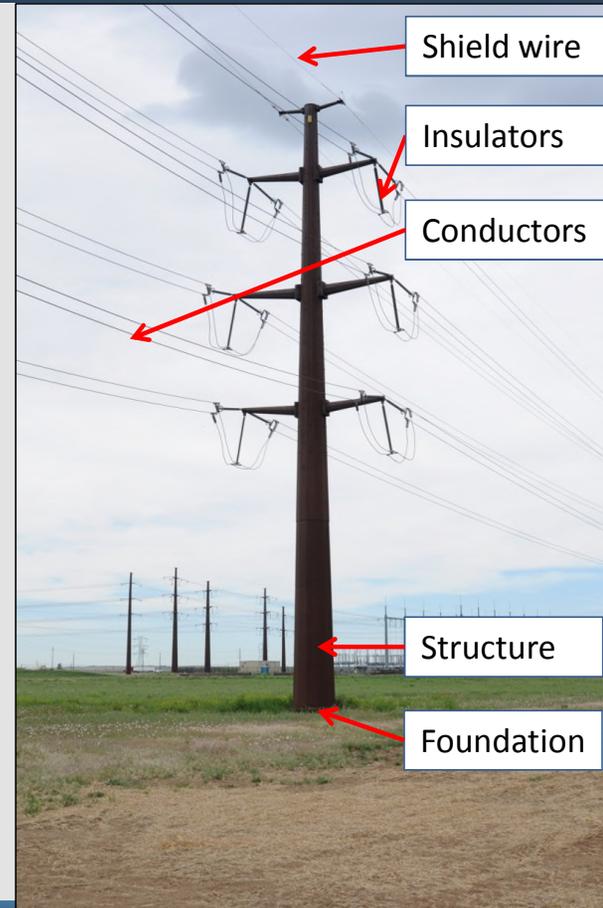
Anatomy of a Transmission Line



Anatomy of a Transmission Line

Overhead Transmission Line Components

- **Shield and Ground wire** – used primarily for protection from lightning strikes and corresponding surges
- **Insulators** – used to contain, separate, or support electrical conductors
- **Conductors** – metal cables used for carrying electric current
- **Structures** – support structures to hold up the conductors
- **Foundation** – system which transfers to the ground the various dead and live loads of the tower and conductors

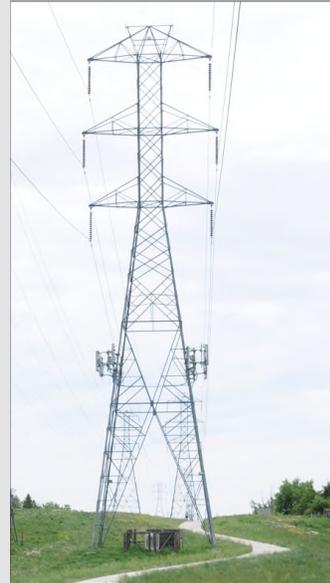


Electricity Generation and Delivery

Electric Operating Systems

Transmission Line vs Distribution Line

- **Transmission Line** - Normally carries electricity at voltages of 69 kV or greater and is used to transmit electric power over relatively long distances, usually from a central generating station to main substations.
- **Distribution Line** - Normally considered to be a line that carries electricity at lower voltages of 12kV to 44kV and is used to distribute power drawn from high-voltage transmission systems to end-use customers.



Transmission Line



Distribution Line



Anatomy of a Transmission Line

Overhead Transmission Line Components

Types of transmission structures



*H-frame
Structure*



*Monopole
structure*



*Lattice
Structure*



*Turning
Structure*



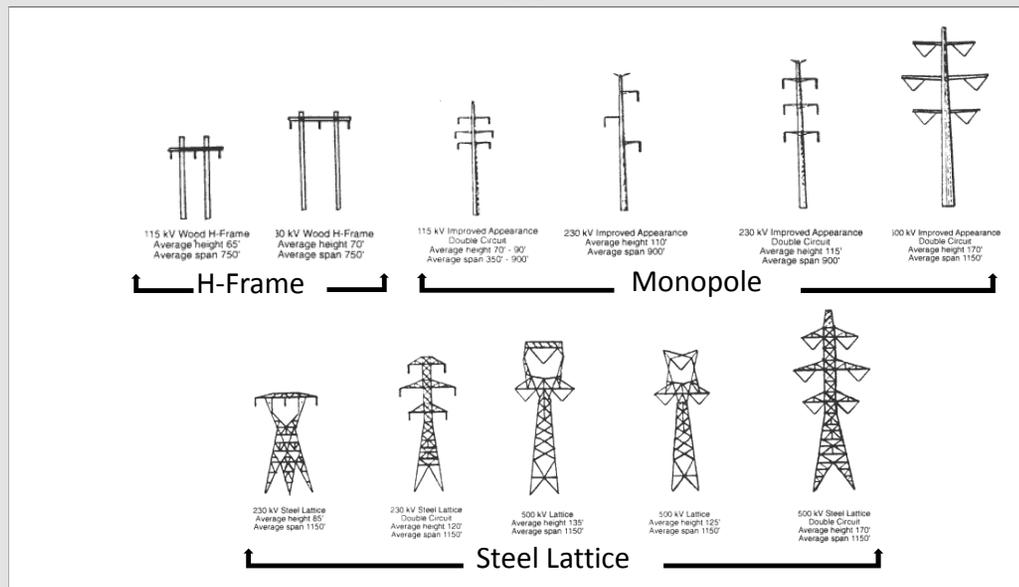
*Underground
Structure*



Anatomy of a Transmission Line

Overhead Transmission Line Components

Alternative Structure Types



Factors that dictate structure types used:

- Size of conductor dictates load carrying capacity
- Company /geographic preference or policy



Anatomy of a Transmission Line

Overhead Transmission Line Components

- **Conductor alternatives**
 - Typically aluminum or copper conductors are used.
 - Aluminum is preferred over copper for its lower cost and lighter weight, however, this comes at the price of some energy loss that doesn't occur with copper.
 - Aluminum Conductor Steel Reinforced (ACSR) – includes steel strands wrapped around aluminum conductors to add strength. This is the most commonly used conductor.



Anatomy of a Transmission Line

Overhead Transmission Line Components

Electrical Discharges: Corona

- **Corona** – electrical breakdown of the air near high voltage conductors into charged particles.
 - Corona can cause audible noise and radio and television interference, electromagnetic interference, insulation damage, etc.
 - Corona from transmission lines can create buzzing, humming, or crackling.

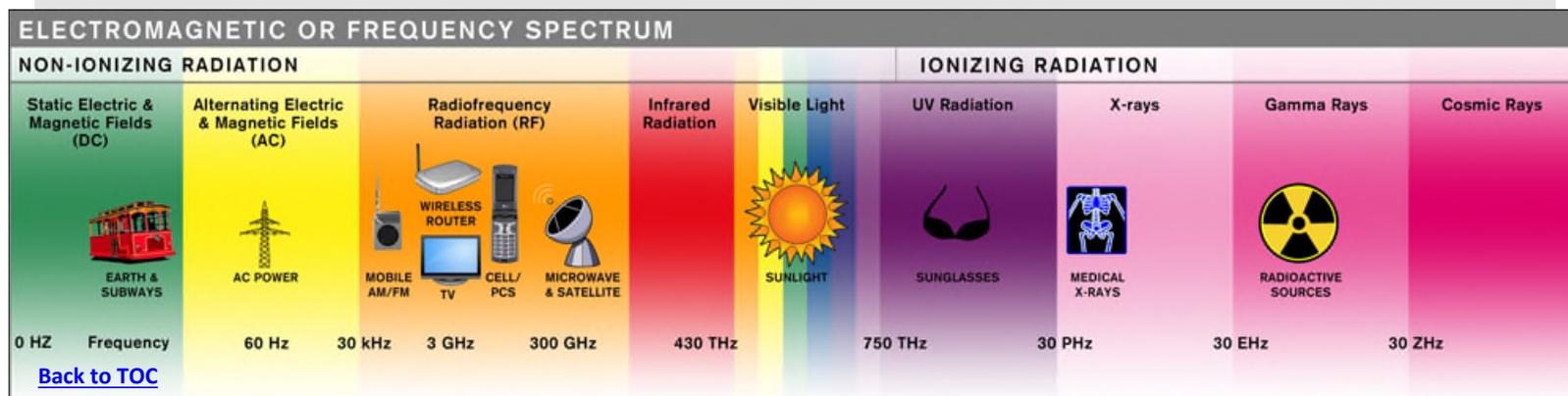


Anatomy of a Transmission Line

Overhead Transmission Line Components

Electrical Discharges: EMF

- **Electric & Magnetic Fields (EMF)** – invisible areas of energy, often referred to as radiation that are associated with the use of electric power. EMFs fall into one of two radioactive categories:
 - **Non-ionizing:** Low-level radiation that is generally perceived as harmless to humans
 - **Ionizing:** High-level radiation that has the potential for cellular and DNA damage



Anatomy of a Transmission Line

Overhead Transmission Line Components

Electrical Characteristics

- **Audible Noise (AN)** – is a measure in units of decibels on a logarithmic scale. Because human hearing is not equally sensitive to all frequencies of sound, certain frequencies are given more “weight.” Noise levels capable of being heard by humans are measured in A-weighted decibels (dBA)

Sound Pressure Level (dBA)	Typical Sources
100-105	Leaf blower
100-104	Circular Saw
84-89	Vacuum Cleaner
76-83	Garbage disposal
68-73	Inside car, windows closed 30MPH
55-65	Normal conversation
50	Background music
40	Living room
28-33	Quiet room

Source:
<http://www.nonoise.org/index.htm>



Anatomy of a Transmission Line

Overhead Transmission Line Components

Electrical Characteristics

- **Radio and Television Interference (RI/TVI)** – Corona discharge can generate radio noise and to a lesser extent television disturbance around high-voltage transmission lines.
 - Typically affects AM radio reception – producing a hissing or crackling noise close to or under a transmission line
 - FM radio reception is rarely affected
 - Television interference typically appears as three bands of “snow” on the television screen.

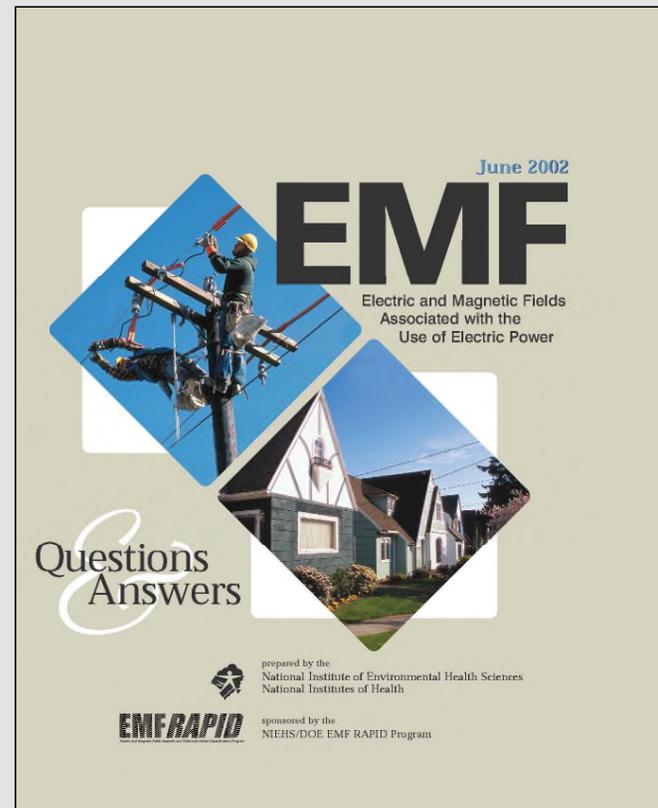


Anatomy of a Transmission Line

Overhead Transmission Line Components

EMF Electric Fields Associated with the Use of Electric Power: Questions and Answers brochure for more information contains more information regarding EMF and is available online at:

http://www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf



About Transmissions Lines

Building/Maintaining Transmission Lines



Building/Maintaining Transmission Lines

Standard Transmission line Design

- **National Electrical Safety Code (NESC) –**
The NESC is the U.S. standard of the safe installation, operation, and maintenance of electric power systems.
- NESC are voluntary standards that are typically adopted as law by individual states.



Building/Maintaining Transmission Lines

Transmission Line Right-of-Way

Transmission Line Right-of-Way (ROW)

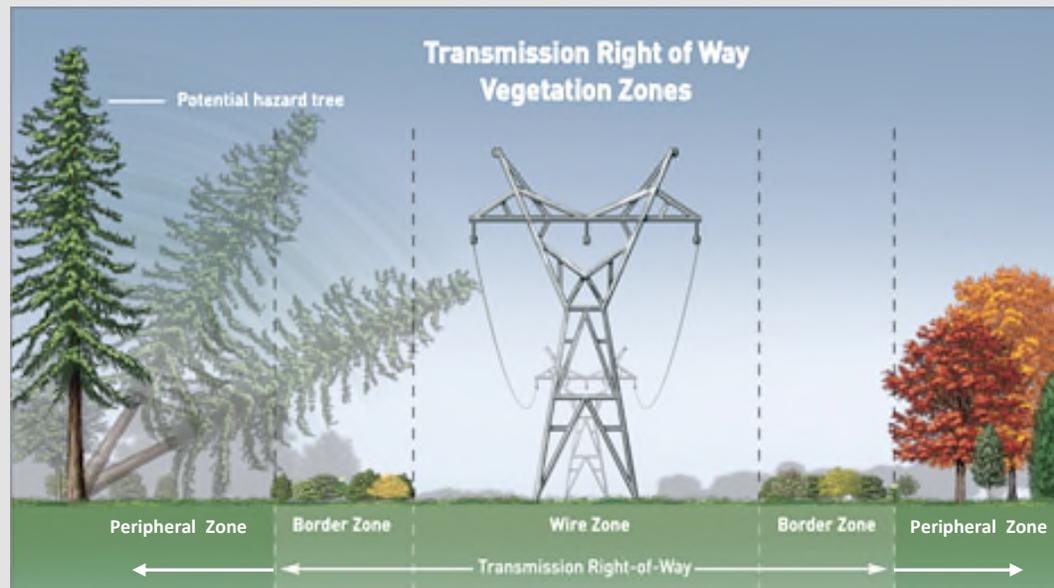
- Used for the construction, operation, and maintenance of a transmission line facility
- May be owned by a utility or granted by an easement
- The width of the ROW is determined by voltage, projected maximum safe distance from conductors, maximum sags and swings, etc.



Building/Maintaining Transmission Lines

Transmission Line Right-of-Way

ROW (Cross-Section)



Wire Zone – This zone is the area directly underneath the conductors and extends from the outermost conductors a few feet that will depend on the voltage of the transmission line.

Border Zone – This zone extends from the edge of the Wire Zone to the outside edge of the ROW. Vegetation in this zone may contain low-growing woody plants and trees.

Peripheral Zone - Zone adjacent to Border Zone.



Building/Maintaining Transmission Lines

Transmission Line Right-of-Way

ROW design considers the following factors:

- Placement of the ROW within the selected route
- ROW width
- Separation between multiple lines
- Access Roads
- Vegetation clearance
- Maintenance and Management

The following design factors are considered in order to minimize impacts:

- Slopes
- Soil types
- Blasting requirements
- Visual impacts
- Sensitive habitats
- Significant structures or locations
- Existing disturbed areas
- Tower placement



Building/Maintaining Transmission Lines

Transmission Line Right-of-Way

Acquisition of Land Rights

- **Negotiation of easements** - Utility companies will typically start by negotiating a fair compensation one-on-one with each property owner and generally acquire easements – which are limited property rights – for power lines and fee simple property for substations.
- **Eminent Domain** - Eminent domain for public uses – such as roads, electricity and water – is in the 5th Amendment to the U.S. Constitution to protect communities' interests. It keeps one person or group from stopping a community from getting the services it needs.
 - Typically used as a last resort after negotiations with landowners



Building/Maintaining Transmission Lines

Standard Transmission line Design

- **Shield wire alternatives**
 - Overhead optical ground wires - combines the functions of grounding and communications
 - Communication circuits
- **Spans between structures (ruling-span, structure spotting, visual, etc.)**
 - Safe horizontal clearance between conductors is often based on the National Electrical Safety Code (NESC)
 - Distance between towers is a function of the electrical conductor to meet sag requirements
 - Distance between lines is to minimize electrical communication (i.e., to prevent interference)



Building/Maintaining Transmission Lines

Overhead vs. Underground

OVERHEAD	UNDERGROUND
Easier to locate damage and repair	Harder to identify and access damaged areas for repair
Lower system loss	Increased system loss
Lower cost to install and maintain	Higher cost to install and maintain
Wider right-of-way or easement	Narrower right-of-way or easement
Environmental concerns	Greater environmental concerns
Greater life expectancy	Life expectancy is about ½ that of overhead transmission
Structures above ground	May require overhead to underground transition structures
Air cooled and widely spaced for safety	Cooling equipment may be required and increases noise above ground
Potentially lower EMF levels	EMF intensity levels may be higher above underground installation
Higher likelihood of accident or attack	Lower chance of accident or attack



Building/Maintaining Transmission Lines

Conventional Construction & Sequencing

- **Conventional construction of transmission lines includes:**
 - Land Surveying
 - Identifying ROW boundaries
 - Flagging centerline of transmission route/structure locations
 - Environmental Resource Surveys
 - Cultural
 - Biological
 - Building access roads
 - Roads are built to construct the transmission line and conduct maintenance on the line after it is in operation.
 - Structure site clearing and vegetation management
 - Construction yards and material staging
 - Construction staging areas are set up for equipment and material storage and worker parking.



Building/Maintaining Transmission Lines

Conventional Construction & Sequencing

- **Conventional construction of transmission lines includes, cont.**
 - Excavation and installation of tower foundations
 - Assembling structures
 - Typically components are delivered and assembled on site at each structure location.
 - Every few miles along the ROW, a work site is set up for equipment to pull and tighten the wires or conductors.
 - Conductor and shield wire stringing
 - Restoring and revegetating disturbed lands
 - Disturbed areas around the structures are restored and revegetated, as required by the property owner or the land management agency.



Building/Maintaining Transmission Lines

Other Methods of Construction

■ Aerial (helicopter) construction

- Used in areas that are hard to access via roads such as in mountainous terrain.
- Used to avoid impacts to sensitive areas (i.e. wetlands, marshes, etc.)



■ Underground construction

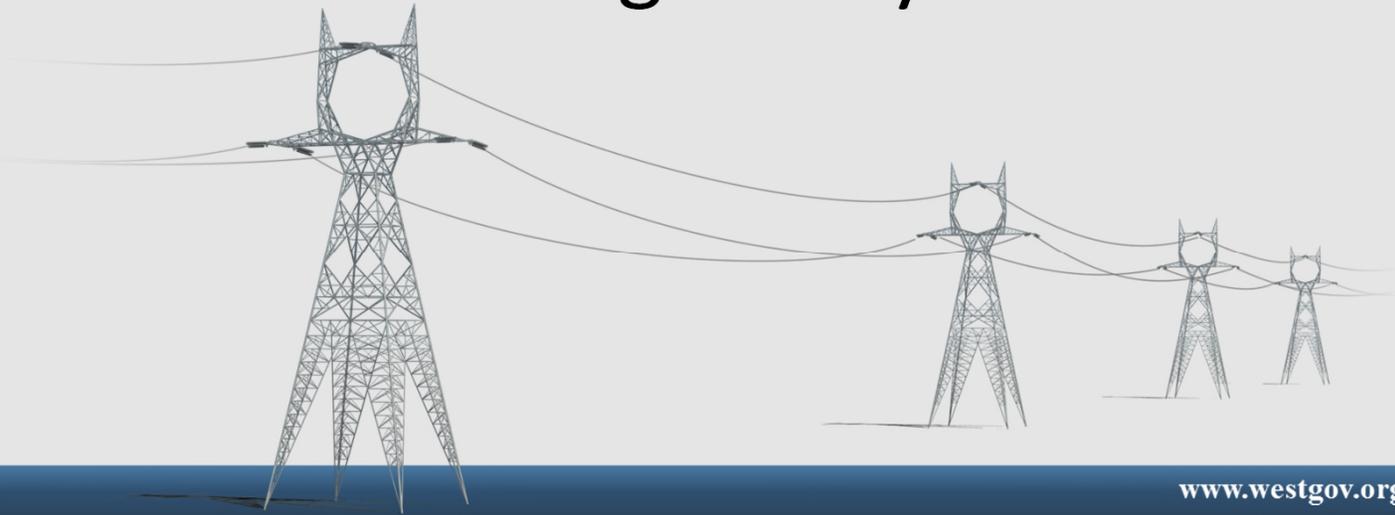
- Typically used in high urban density populations where ROW easement may not be easily obtained or to avoid sensitive habitat areas.
- Two significant technical challenges in construction of underground lines:
 - 1) Need to provide sufficient insulation so cables can be close to grounded materials.
 - 2) Need to dissipate the heat produced during the operation of the electric cables.





Bangladesh Trustful Firefighting

Electric Power Transmission: Planning the System



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Planning the System

- **Goals of Transmission Planning:**
 - Meet policy requirements
 - Renewable portfolio standards
 - Energy efficiency
 - Greenhouse Gas emissions
 - Meet reliability needs
 - Peak loads
 - Normal and abnormal conditions
 - Meet customer needs
 - Cost effective/economical
 - Provide uninterrupted service
 - Meet the public's needs
 - Minimize impacts to land uses, private lands, and the environment



Planning the System

- **Agencies/Organizations that plan transmission lines:**
 - Federal
 - Department of Energy (DOE)
 - National Interest Electric Transmission Corridors (NIETC) – Regions created by the DOE in an effort to speed the creation of more transmission capacity
 - Regional/Interconnection Level
 - 8 Regional Entities
 - 8 Independent System Operators (ISO)
 - 4 Regional Transmission Organizations (RTO)
 - Subregional Planning Organizations
 - Utility Level



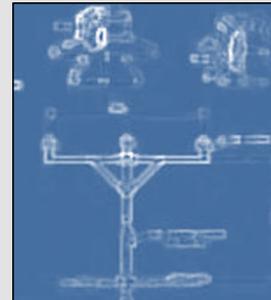
Planning the System

- **FERC Order 890 requires transmission providers' planning processes to meet the following principles:**
 1. Coordination openness transparency
 2. Information exchange
 3. Comparability
 4. Dispute resolution
 5. Regional participation
 6. Economic planning
 7. Cost allocation for new projects



Project Level Planning

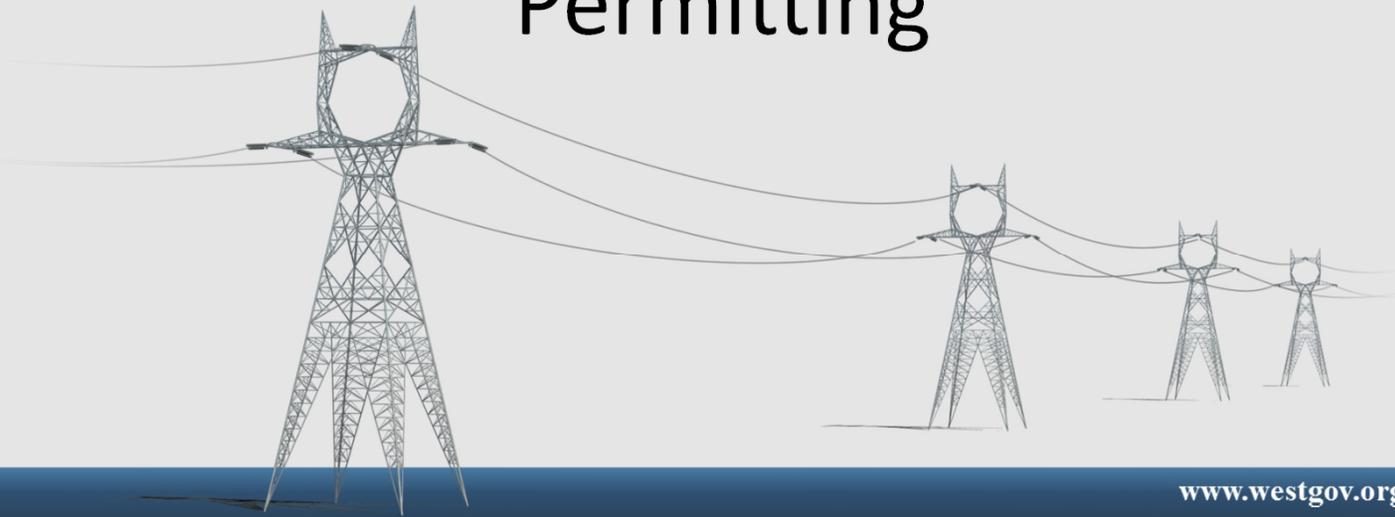
- System planning
- Project planning
- Routing
- Public outreach
- Licensing and environmental
- Conceptual engineering
- Detailed design
- Material procurement
- Construction contracts
- Construction management
- Construction completion





Bangladesh Trustful Firefighting

Electric Power Transmission: Permitting



Permitting Transmission Lines

- Construction of new transmission facilities typically needs approval from several federal and state agencies
- Federal decisions will follow the National Environmental Policy Act (NEPA) processes for federal approval
- State and local decisions will follow state or local specific regulations and protocols
 - Some states have siting authority



Federal Regulations

- **Federal entities that may have authority over transmission line siting, market structure, NEPA, etc.**
 - Federal Energy Regulatory Commission (FERC)
 - Regulates interstate transmission rates for public utilities
 - Department of Energy (DOE)
 - Department of Agriculture - Forest Service
 - Special Use Permit
 - Department of Agriculture – Fish & Wildlife Service
 - Endangered Species Act Section 7 Consultation
 - Avian and Bat Protection Plan
 - Migratory Bird Treaty Plan



Federal Regulations

- **Federal entities that may have authority over transmission line issues, cont....**
 - Department of Interior - Bureau of Land Management
 - SF 299 (ROW Authorization permit)
 - ROW Grants
 - Plan of Development
 - Department of Commerce
 - Environmental Protection Agency (EPA)
 - Council on Environmental Quality (CEQ)
 - Advisory Council on Historic Preservation



State Regulations

- State agencies that may have authority over transmission issues
 - Public Service/Public Utility Commission
 - State Environmental Agencies
 - State Legislatures/State Siting Acts
 - Local Authorities
- Transmission issues overseen by state agencies may include rates, siting, land use, or setting environmental standards



State Regulations

- Rules and regulations overseeing the siting and permitting of transmission lines vary state to state.
- Some states have specific siting authority for transmission infrastructure.
- Some states do not have centralized siting authority and transmission line siting authority falls to local municipalities (counties, cities, towns, etc.).



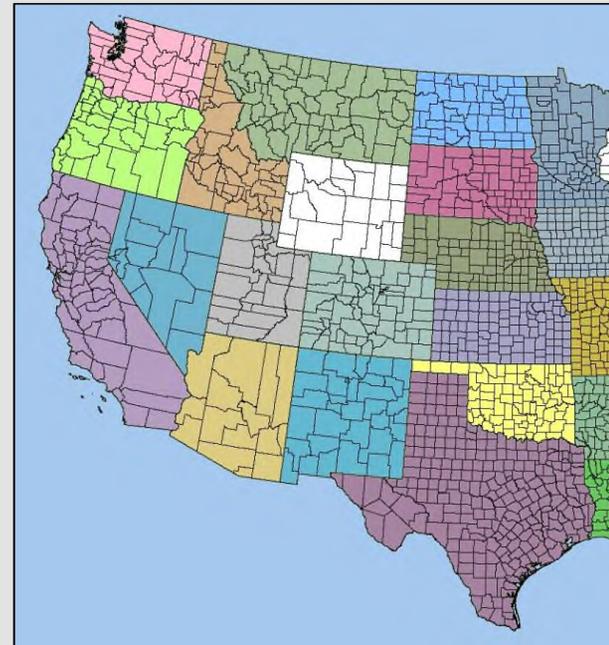
State Regulations

- Land use, contracts, eminent domain, and public utility status are usually regulated by state law.
- Most state siting authorities include environmental and social impact analysis.
- Municipal utilities and cooperatives are not regulated by the state.



Local Regulations

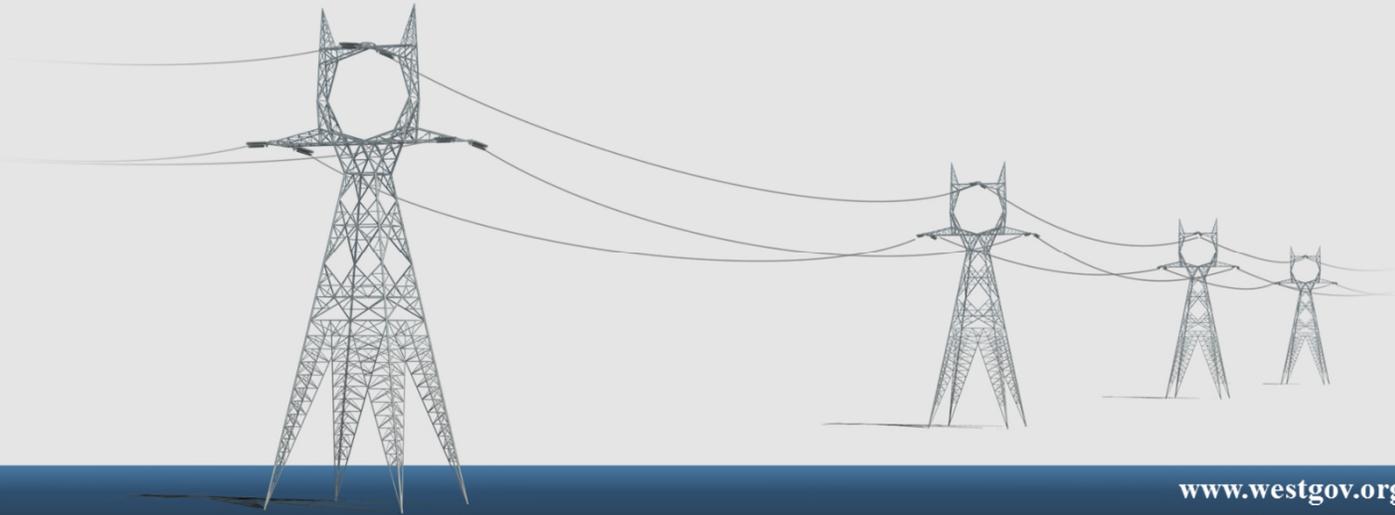
- **Permits that may be required at the local level:**
 - Special Use Permit
 - Conditional Use Permit
 - Building Permit
 - Development Agreements
 - Grading Permit
 - ROW Encroachment Permit
 - Dust Control Permit





Bangladesh Trustful Firefighting

Electric Power Transmission: Potential Environmental Impacts



Potential Environmental Impacts

- Unlike locating a substation or power plant that has a single location, transmission lines require development across many miles; thus avoiding impacts to environmentally sensitive areas is not always possible.
- Transmission owners try to select a route that balances environmental factors with other considerations such as engineering, community and landowner input, costs, etc.



Potential Environmental Impacts

Environmental impacts from development of a transmission line can occur to the following:

- Aesthetic/Visual Resources
- Cultural/Archaeological Resources
- Endangered/Threatened and Protected Species
- Geologic/Seismic
- Invasive Species
- Water Resources – including lakes, streams, floodplains
- Wetlands
- Wooded and Forested Areas
- Others...



Aesthetics/Visual

- **Impacts on Aesthetic/Visual Resources**
 - Removal of a resource, such as clearing a forested area, fencerows in rural areas, etc.
 - Intrude on the view of a landscape, thus degrading the surrounding environment
 - Can invoke an image of development in a previously rural or natural setting, thus changing the context of the view shed



Aesthetics/Visual

- **Mitigation of Aesthetic/Visual Impacts**
 - Transmission structures can be modified to reduce contrast (i.e. type of structure used, materials, coating)
 - ROW management
 - Plant vegetative screens
 - Leave the ROW in a natural state at road or river crossings
 - Structure location – site in areas where the structure may be screened by existing topography or vegetation



Cultural/Archeological Resources

- **Impact on Cultural/Archeological Resources**
 - Archeological/historic sites can be damaged
 - Artifacts can be crushed or damaged
 - Sites can become exposed to erosion or the elements
 - Sites may become more accessible to vandals



Cultural/Archeological Resources

- **Mitigation of Cultural/Archeological Impacts**
 - Conduct a records search to determine the presence of known archaeological sites/historic structures
 - Site transmission structures away from known archaeological site/historic structures
 - Develop a cultural resource management plan
 - Keep equipment and vehicles within the limits of initially disturbed areas (i.e., roads, staging areas)



Endangered/Threatened and Protected Species

■ **Impacts on T&E Species**

- Plants/animals or their habitats can be destroyed during construction.
- Water quality can be degraded by soil siltation into rivers during construction.
- Construction can disturb a habitat during active nesting or spawning periods of protected species.
- Removal of trees and brush in wooded or wetland areas can increase edge effects, making the area unsuitable for rare plants or animals.
- Environmental groups raised an issue recently that hawks were hunting sage grouse from atop power line poles.



Endangered/Threatened and Protected Species

- **Mitigation of T&E Species Impacts**
 - Minimize or modify the route
 - Transmission line design
 - Reduce the workspace at certain locations
 - Use special construction techniques



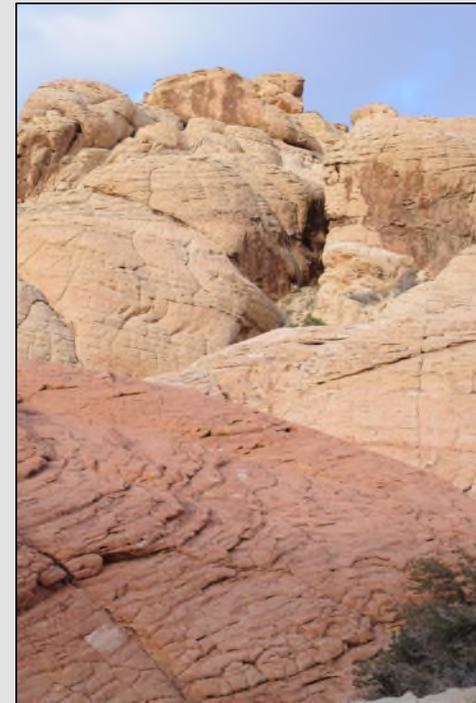
Geologic/Seismic

- **Impacts on local geologic features**
 - Implementation of access roads may create stability issues
 - Aggregate sources must be identified
 - Faults and landslide risk areas should be identified
 - Foundation design implications
 - Construction blasting in shallow bedrock could have impacts on unstable landforms



Geologic/Seismic

- **Mitigation for local geologic features**
 - Identify access road alignments
 - Map and quantify aggregate sources
 - Avoid faults and landslide risk areas
 - Alignments and tower locations are placed away from faults and unstable soils
 - Design foundations to match soil and rock characteristics



Invasive Species

■ **Impacts by Invasive Species**

- Construction can contribute to the spread of invasive species
- Invasive species can spread and impact adjacent properties



Invasive Species

- **Mitigation of Invasive Species**
 - Survey and avoid areas populated with invasive species
 - Construct during times of year when invasive species are less likely to be encountered or spread
 - Plan construction access points/staging areas to minimize ground disturbance
 - Clean equipment to prevent spreading
 - Stabilize exposed soils by using effective erosion controls and stormwater management practices



Water Resources

- **Impacts on Water Resources**
 - Impacted by work within waterways
 - Removal of vegetation along banks can cause river temperatures to rise and increase erosion and sedimentation deposits



Water Resources

- **Mitigation of Impacts to Water Resources**
 - Avoid impacts by rerouting the line away from waterways
 - Adjust pole placement to span waterways
 - Construct the line under the waterway
 - Use temporary bridges to avoid driving equipment through waterways
 - Implement erosion controls during and after construction activities



Wetlands

- **Impacts on Wetlands**
 - Loss of wetlands
 - Spread of invasive species
 - Fragmentation of wetland types



Wetlands

- **Mitigation of Impacts to Wetlands**
 - Reroute the line away from wetlands
 - Adjust pole location to span the wetland overhead
 - Bore the line under the wetland



Wooded and Forested Areas

■ Impacts to Wooded and Forested Areas

- Forest fragmentation – making interior forest species more vulnerable to predators, parasites, etc.
- Reduction of suitable habitat for species that require large undisturbed blocks of forest habitat
- Invasive species can be introduced and spread
- Removal of riparian woodlands along waterways can affect water quality



Wooded and Forested Areas

- **Mitigation of Impacts to Wooded and Forested Areas**

- Avoid routes that fragment major blocks of forest land
- Adjust pole placement and span length to minimize the need for tree removal and trimming along forest edges
- Allow tree and shrub species with a maximum height of about 12 to 15 feet to grow within the ROW



Efforts to Avoid or Minimize Impacts

- Transmission owners will typically collaborate with regulatory agencies, land owners, communities and other stakeholders early in the planning process to understand possible environmental concerns with the development of transmission project.
- Information obtained during consultation with agencies and stakeholders is incorporated into the route selection process.
- Continue to communicate with agencies and stakeholders during the review process to address additional concerns.

