Transmission Basics

Facilities, Interconnection and Permitting

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Overview

- Basics regarding electrical system
- Basics of transmission planning
- Basics regarding interconnection
- Basics of typical siting/state permitting processes for transmission lines

Useful Links

- EEI siting directory of agencies http://www.eei.org/ourissues/ElectricityTransmission/Documents/State_Generation_Transmission_Siting_Directory.pdf
- OSHA illustrated glossary of electrical components http://www.osha.gov/SLTC/etools/electric_power/illustrated_glossary/index.html
- The Design, Construction and Operation of High Voltage Transmission lines http://solareis.anl.gov/documents/docs/APT_61117_EVS_TM_08_4.pdf

Electrical System Elements…

- Interconnected power systems are the largest physical machines in existence.
- Electrical “grids”- energy is generated and used constantly in the same amounts. To keep it balanced operators will ramp power up or down, or drop load.
- Selective list of basic grid components:
  - generators
  - substations/equipment
  - transmission lines
  - distribution lines

Diagram of Generation, Transmission, Distribution System

- A typical power generation, transmission and distribution system has these components:
- Power Generation Plants
- Substations
  - Step-up Transmission Substation
  - Step-down Transmission Substation
  - Distribution Substation
  - Underground Distribution Substation
  - Substation Functions
  - Substation Equipment
- Transmission Lines
  - Overhead Transmission Lines
  - Subtransmission Lines
  - Underground Transmission Lines
- Distribution Systems
  - Industrial Customer
  - Commercial Customer
  - Residential Customer
  - Transportation Customer

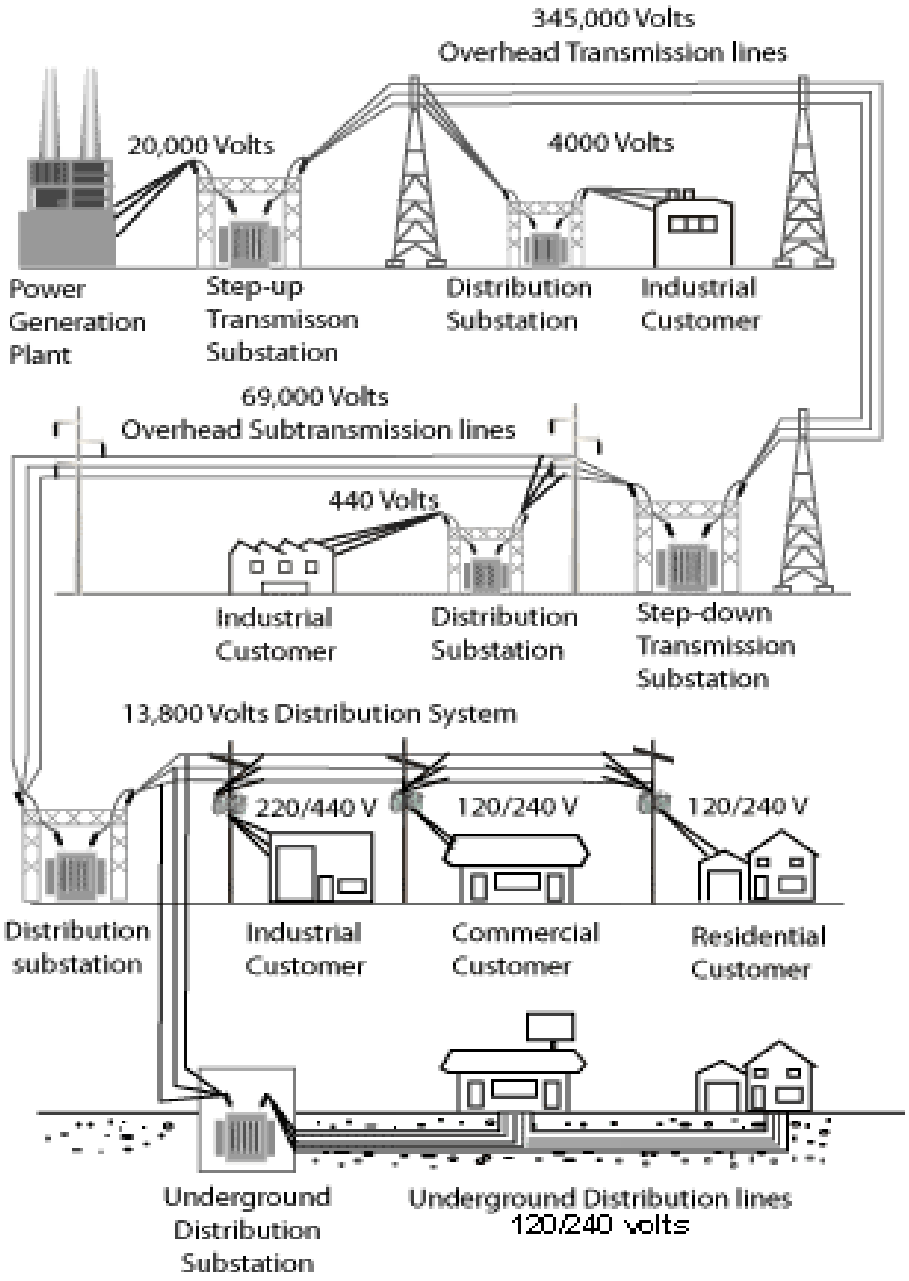
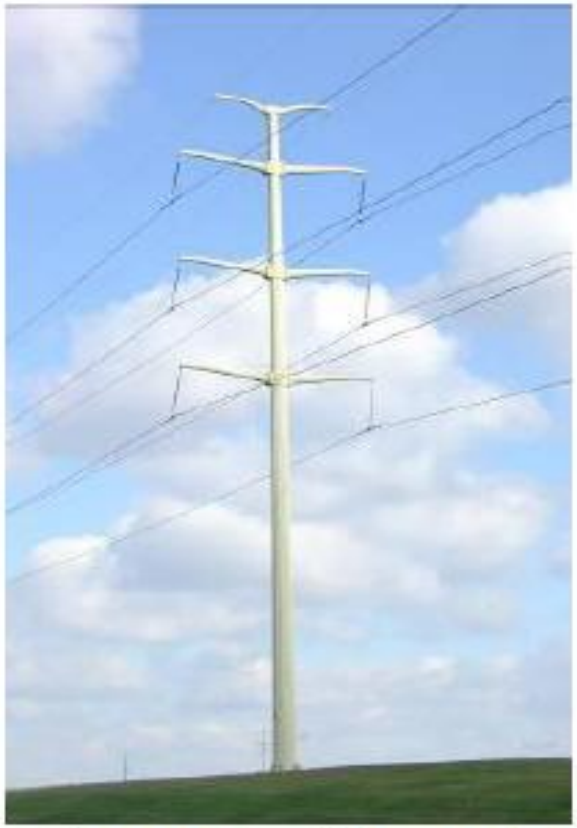


Figure 1. Diagram of the Power Generation, Transmission and Distribution System

Transmission Line Towers

Single Circuit,



Double Circuit

Multiple Circuit

A substation is a high-voltage electric system facility. It is used to switch generators, equipment, and circuits or lines in and out of a system. It also is used to change AC voltages from one level to another, and/or change alternating current to direct current or direct current to alternating current. Some substations are small with little more than a transformer and associated switches. Others are very large with several transformers and dozens of switches and other equipment. There are three aspects to substations:

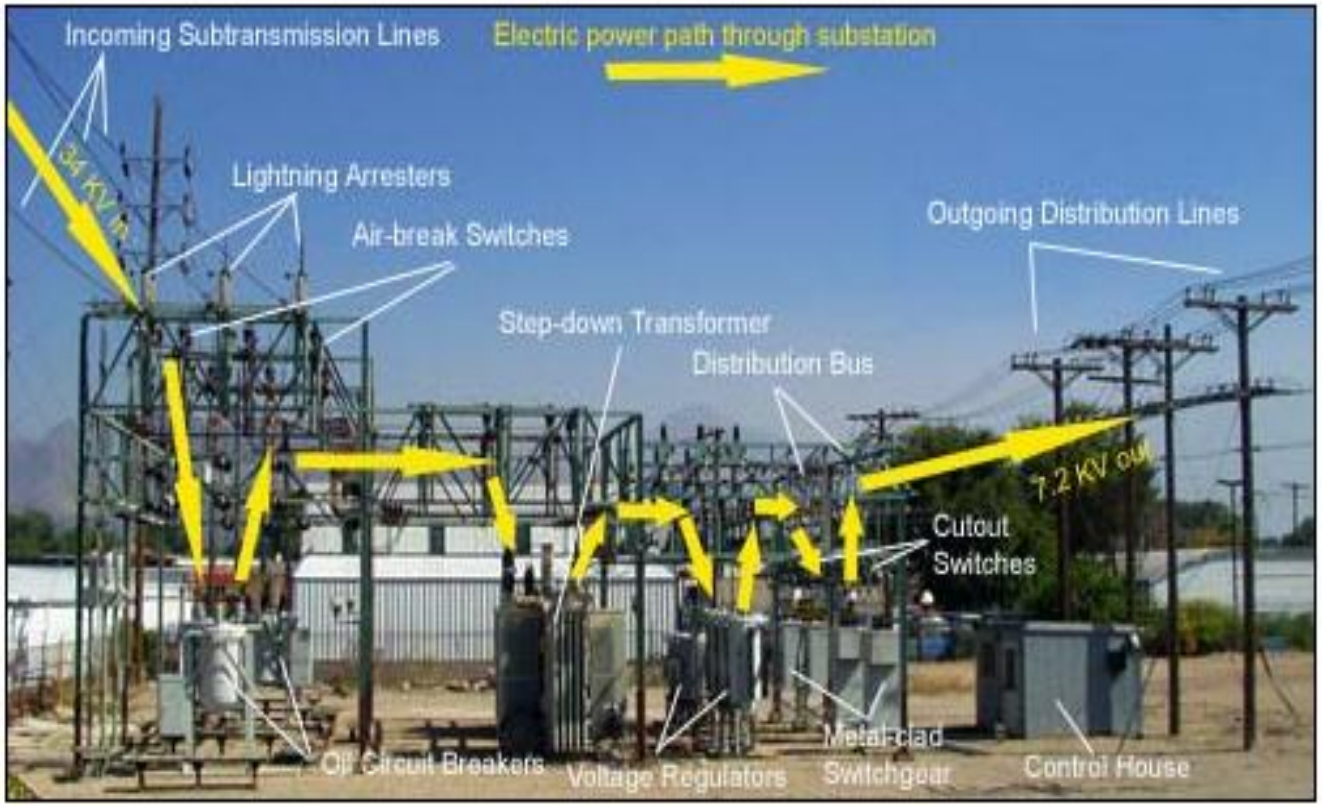


Figure 1. Typical substation

Step-up Transmission Substation

TOP

A step-up transmission substation receives electric power from a nearby generating facility and uses a large power transformer to increase the voltage for transmission to distant locations. A transmission bus is used to distribute electric power to one or more transmission lines. There can also be a tap on the incoming power feed from the generation plant to provide electric power to operate equipment in the generation plant.

A substation can have circuit breakers that are used to switch generation and transmission circuits in and out of service as needed or for emergencies requiring shut-down of power to a circuit or redirection of power.

The specific voltages leaving a step-up transmission substation are determined by the customer needs of the utility supplying power and to the requirements of any connections to regional grids. Typical voltages are:

High voltage (HV) ac:	69 kV, 115 kV, 138 kV, 161 kV, 230 kV
Extra-high voltage (EHV) ac:	345 kV, 500 kV, 765 kV
Ultra-high voltage (UHV) ac:	1100 kV, 1500 kV
Direct-current high voltage (dc HV):	±250 kV, ±400 kV, ±500 kV

Direct current voltage is either positive or negative polarity. A DC line has two conductors, so one would be positive and the other negative.

Figure 2. Step-up AC transmission substation

Figure 3. Step-up transmission substation to AC transmission lines

Regulatory Background Planning

- **Federal Authority: FERC, NERC**
  - FERC has authority over wholesale (interstate commerce) transmission rates; States have authority over rates for projects that affect only in-state rate-payers such as distribution projects
  - NERC sets standards which utilities must obey or be fined
  - NEPA required if Federal nexus such as crossing public land
- **ISO/RTOs**
  - Authority for regional planning
  - Authority for setting up wholesale markets
- **FERC Order 1000**
  - Requirement for participation in regional planning
  - Must incorporate public policy into planning
  - Discontinue utility right of first refusal – hence competitive projects
  - Cost allocation required

Basics of Transmission Planning…

- Electrical “grids” are interconnected regional systems. An event in one location, affects other locations. To ensure reliable operation the system must be in balance at all times.
- Planning is performed in collaborative forums, to ensure that the system will operate reliably in accordance with technical standards-- NERC
- These forums include:
  - WECC, WestConnect ,ISOs
  - Sub regional forums
  - Participants in combined ownership facilities

Basics of Transmission Planning…

- Transmission plans are often evaluated in forward looking ten year plans, and are refined as circumstances change. It typically takes longer to develop, permit and construct a transmission line than it does to develop a generation facility.
- FERC has required that transmission planning processes be open, and transparent, and that stakeholders have access to the planning forums.
- Planning forums will usually provide a means of public notification of planning activities.
- Some states conduct a review of its utilities' transmission plans to ensure they are adequate.

Basics of Transmission Planning…

- Merchant lines plan to sell transmission capacity to utilities and interconnectors
- Public utilities plan to:
  - Ensure adequate transmission from resources to serve loads in a reliable and economical manner.
  - Support individual utilities and customers. local transmission and distribution systems.
  - Provide for interconnection of new resources.
  - Accommodate requests for long term transmission access

Basics of Interconnection

- Transmission planning used to mean adding elements to an existing system which was built up over decades to accommodate the needs of load serving entities (companies serving consumers) who built their own generation facilities. In the West- history of joint ownership.
- Now planning must include elements needed by merchants.
- The Energy Policy Act of 1992 required all FERC jurisdictional entities to provide open, non discriminatory access to the transmission systems for merchant generators, no one has a special status, first come, first served.
- FERC provided a template for handling requests by generators (large and small) in the form of Large/Small Gen. Interconnection procedures. (Many public power entities have adopted substantially similar procedures.)
- Generator is required to pay costs for transmission lines and necessary system upgrades. Gen must also pay transmission charges. Generator recover the costs for system upgrades by means of credits against transmission charges.

Technical Interconnection process

- Generator files application
  - Deposit required-amounts have increased to cover costs and ensure applicants have "real" projects
  - Type of service, location, MWs, commercial operation date, technology to be used (natural gas, wind, solar, hydro, coal, nuclear) site control
  - When complete, project is in "queue"; projects studied in order applications received (can be studied in groups or "clusters"
  - Cannot sell place in queue- can sell the project
  - Meeting with transmission provider (TP) to discuss the project and potential alternative interconnections.

Feasibility Studies

- The first technical study
  - Deposit required, site control
  - A preliminary evaluation of system impact and costs of interconnecting project to system
  - Considers other projects earlier in time in the queue which may impact this project
  - Some developers skip this step and proceed to system impact studies

System Impact Studies

- Evaluates reliability impact of project on transmission system
- Additional technical studies
- Will identify requirements, preliminary estimate of time and costs to correct problems, list of facilities required and good faith estimates of construction costs and cost responsibilities
- Developer receives a draft agreement for next study (Facilities Study)- MUST be signed within time period, and any additional technical information MUST be provided

Facilities Study

- The final and most detailed study and estimate of costs of equipment, engineering, procurement with timelines
- TP will coordinate this study with any affected transmission system
- 90 day delivery will have a +/- 20% est.
- 180 day delivery will have +/- 10% est.

Key Challenges and Issues in Transmission Line Development

- Siting
  - Engineering
  - Permitting
- Public Involvement
  - Inform/solicit input from stakeholders
- Right-of-Way Acquisition
  - By purchase
  - By Eminent Domain

Transmission Siting

- Focus is on high-voltage transmission - normally defined as anything over 69-kV
- States typically regulate siting of new lines above 100-kV
- Most states require some type of Approval, such as a “Certificate of Convenience and Necessity”
- EEI has listing of State specific requirements

Transmission Siting - Process

- **How are new transmission lines sited?**
- Process involves traditional Opportunity/Constraint Analysis
- Opportunities include – paralleling existing lines; paralleling roads or railroads; and crossing open land
- Constraints include – wetlands, historic structures and sites, residential areas, and other environmentally sensitive areas; engineering and construction requirements

Public Involvement

- State compliant notification
- Media relations
- Stakeholder identification
- Public meeting design and facilitation
- Public information and education
- Web site design and development, online public comment management
- Printed materials design and graphics
- Visual resource impact analysis
- Videos, motion graphics, 3D animation

Right-of-Way Acquisition

- “Fee simple” acquisition of property is limited
- Most right-of-ways use easements where land owners are paid fair market value for use of property
- Land owner and community concerns over reduction in property values – studies are inconclusive
- Eminent Domain – utilities may have right to “condemn” land through court action if owner refuses to sell – utility must prove need for land – owner still receives fair market value-and severance damages

Potential Permits

- Local
  - Site plan approval
  - Land use authorization
  - Drainage and construction
- Environmental
  - NEPA, ESA,
  - Clean Water Act, Air emissions
  - Cultural Resources
- State approvals
  - State Land - granting ROW, may require environmental and cultural studies
  - Public Utility Commissions, which determine need for project or issue CCN.
  - Siting Authorities which evaluate environmental compatibility

Typical Transmission Project Needs

- **ROW Services**
  - **Survey**
  - **ROW Acquisition and Support**
  - **Feasibility Studies**
  - **GIS / Mapping**
  - **Alternatives/Constraints Analysis**
  - **Expert Witness Testimony**
- **Permitting**
  - **Agency Coordination**
  - **NEPA Documentation**
  - **Wetlands Delineation**
  - **Threatened and Endangered Species**
  - **Cultural Resources Permitting**
  - **Mitigation Design**
- Community Involvement
  - **Planning and Implementation**
  - **Web Site Design and Implementation**
  - **Visual Simulation**
- **Civil/Geotechnical Engineering**
  - **Sub-surface investigation**
  - **Foundation Design**
  - **Erosion and Sediment Control**
  - **NPDES Permitting**

- **Program Management; PM, CM**
- **Design Engineering**
  - **Transmission Design**
  - **Protection and Controls Design**
  - **Microwave Design**
  - **Substation Design and Specifications**

Useful Links

- WGA Transmission Roadmap and appendices http://www.westgov.org/reports?view=reports&start=4
- Design, Construction and Operation of …Transmission Technologies http://solareis.anl.gov/documents/docs/APT_61117_EVS_TM_08_4.pdf
- Illustrated Electric power glossary http://www.osha.gov/SLTC/etools/electric_power/illustrated_glossary/index.html