Senior Design Team 18 - May 2024 Lightning Talk #1

Baylor Clark, Liam Grossman, Eduardo Jimenez-Tzompaxtle, Siti Mohd Radzi, Eli Schaffer, Chicheng Tang

Safety Moment - Personal Protective Equipment

Why is it important?

- Prevent personal injuries/fatalities
- Protect equipment from improper use
- Ensures minimal exposure to hazards

What to use and when to use it

- Hard hats should be worn in active construction sites as well as sites with overhead equipment or potential falling debris
- Steel toe boots should be worn in active construction sites as well as in environments where there is a reasonable expectation of hazardous walkways
- Arc flash/fire retardant suits should be worn when handling energized high voltage equipment

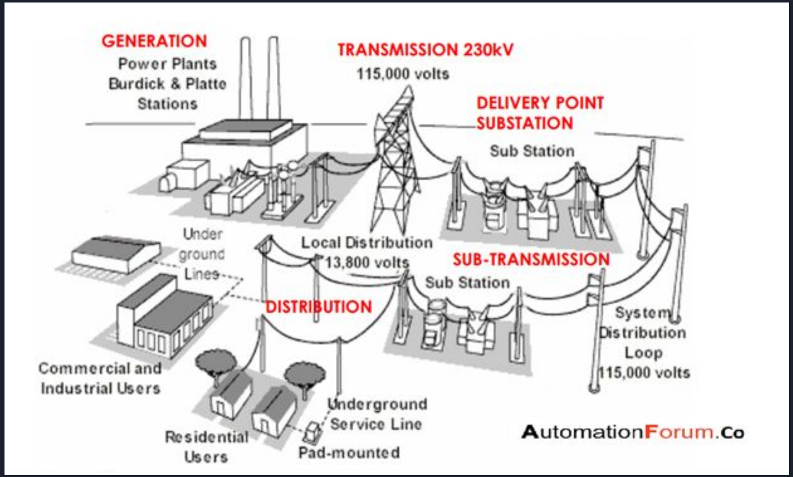
[Substation Link](#) [Solar Field Link](#)

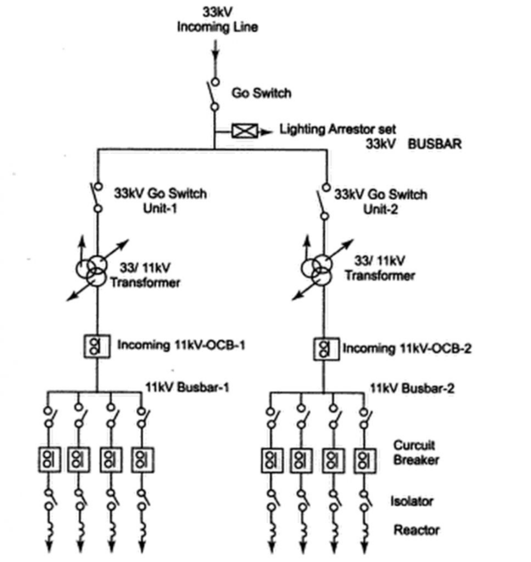
Project Information

Due to increasing Renewable Energy requirements for utilities, a 115/34.5kV Distribution substation and 60MW Solar Plant will need to be designed by Iowa State University. We as the project team are responsible for the complete design of Solar layout, Electrical layout, and associated construction deliverables. We project team will also perform various calculations required of a typical substation, including load-flow analysis, short-circuit studies, system protection design, and grounding calculations.

Substation Overview

Transmission lines come into substation at 115 kVA. These lines then step down into transformers which take the voltage from 115 kVA to 34.5 kVA. The line then goes through switchgear to help service in case of a disaster. After the switchgear, the lines go to busbars which help distribute the voltage to different lines to be distributed.





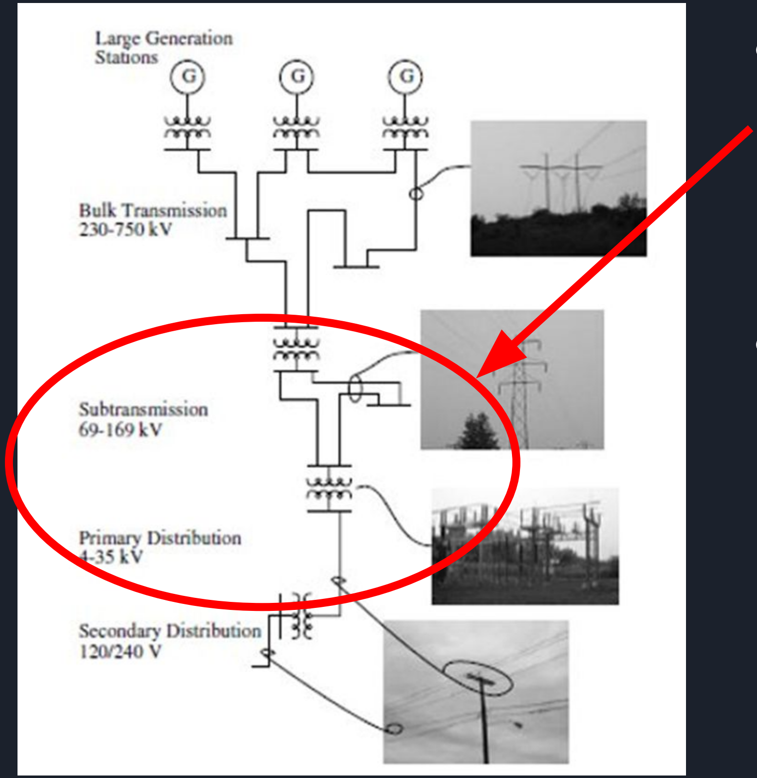
Feeders -> SG -> XFMR -> SG -> Circuit Breaker -> Busbar -> Outgoing Feeders

The circuit diagram to the left shows an overview of a typical substation circuit. This shows a 33/11 kVA system and transformer, but similar principles apply to our project.

https://www.watelectrical.com/electrical-substation-definition-layout-uses-of-substations/

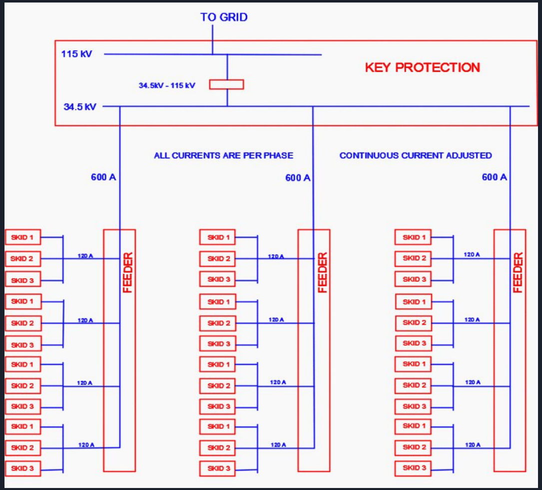
https://automationforum.co/introduction-to-electrical-substation/

Electricity Infrastructure – Solar Farms (PV systems)



- Solar Farms (Photovoltaic systems) are usually interconnected to the grid at either the **sub-transmission voltage** or **primary distribution level**.
- Solar systems provide a DC output that must be inverted and stepped-up before making a network (grid) interconnection.

Requirements - Deliverables



Substation Drawing Image

- Equipment sizing calculations (breakers, transformers, etc)
- Bus calculations for substation
- Possibility of additional calculations (DC battery bank, lightning protection, etc.)
- Solar layout drawings and solar panel string sizing design
- Electrical layout drawings (substation equipment)
- Grounding analysis and ground-grid developed with IEEE-80
- Coordination Study / AC Arc Flash Study / Protection Element Analysis
- Creation of solar/substation design-optimizing tool
- Simulation of designed substation
- Load Flow Scenario Wizard / Configuration Manager

Requirements - Classes and Programs

E E 303: Energy Systems and Power Electronics

E E 455: Introduction to Energy Distribution Systems

E E 456: Power System Analysis I

E E 457: Power System Analysis II

E E 458: Economic Systems for Electric Power Planning

Class Picture Link

Engineering Standards - Software

ACAD- A computer-aided design(CAD) software

- Drifting & Designing
- Documentation & Presentation

ETAP- Electric network modeling and simulation software

- Protection Coordination
- Reliability Analysis
- Cable Sizing
- Renewable Energy Integration

Bluebeam- Create, Markup, and Editing PDF software

- Document Review & Annotation
- Collaboration
- Measurement Tools

Engineering Standards - IEEE

IEEE (Institute of Electrical and Electronics Engineers) standards cover a wide range of topics related to electrical and electronic technologies. These standards are developed through a consensus-based process involving experts from academia, industry, and government. IEEE standards are used to ensure interoperability, safety, and quality in various fields. The IEEE has several standards related to the design of solar power plants and substations. These standards cover a wide range of topics, including safety, performance, and grid integration. Here are some key IEEE standards related to solar power plant and substation design:

Advancing Technology for Humanity

IEEE SA STANDARDS ASSOCIATION

IEEE 1547: Standard for Interconnecting Distributed Resources with Electric Power Systems:
- This standard provides guidelines for the interconnection of distributed energy resources, including solar power plants, with electric power systems. It addresses safety, power quality, and grid integration requirements.

IEEE 929: Recommended Practice for Utility Interface of Photovoltaic (PV) Systems:
- This standard provides recommendations for the design and operation of utility interfaces for PV systems. It covers issues such as voltage regulation, protection, and power quality.

IEEE 1584: IEEE Guide for Performing Arc-Flash Hazard Calculations:
- While not specific to solar power plants, this standard is important for assessing arc-flash hazards in electrical systems, including substations. Safety is a critical aspect of substation design, and this standard provides guidance for arc-flash hazard calculations.

IEEE 2030.5: Standard for Smart Energy Profile Application Protocol:
- This standard focuses on the communication protocols and interfaces for smart grid systems, which may be relevant for solar power plants and substations involved in grid integration and control.

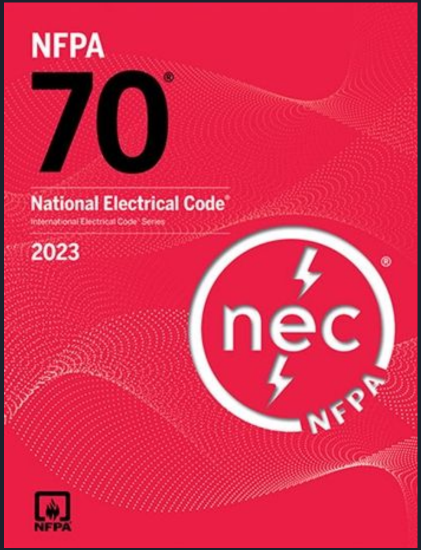
IEEE 1547.1: Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems:
- This standard provides test procedures to determine whether equipment used in distributed energy resources, such as inverters in solar power plants, conforms to IEEE 1547 requirements.

IEEE 3001.9: Recommended Practice for the Characterization of Photovoltaic (PV) Inverters in Utility Interactive Applications:
- This standard provides guidelines for characterizing the performance of PV inverters used in utility interactive applications, which is crucial for designing reliable solar power plants.

IEEE 80: Guide for Safety in AC Substation Grounding:
- Substation design is an integral part of solar power plant design. This standard provides guidelines for safe grounding practices in AC substations, ensuring safety for both personnel and equipment.

IEEE 141: Recommended Practice for Electric Power Distribution for Industrial Plants:
- This standard provides recommendations for the design and layout of electrical systems in industrial plants, including substations that may be part of a solar power plant.

Engineering Standards - NEC



NEC Image Link

- Created and updated by the National Fire Protection Association
- Purpose of NEC is to safeguard the public and property from any electrical hazards
- Depending on region and state different iterations of the NEC are used
  - Bigger cities and municipalities typically use newer iterations
  - More common for rural areas to adhere to older iterations
- Each sections provides specific guidelines for the design and construction of electrical infrastructure
  - Wiring
  - Electrical Equipment
  - Occupancy and Building Type