Senior Design
Team 41 – May 2025
Lightning Talk #1

115/34.5kV Solar Plant & Substation

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Safety Moment - Personal Protect Equipment for Solar Workers

The use of personal protective equipment (PPE) is vital for safeguarding workers during solar installations. Key PPE items for solar workers typically include:

- Hard hats.
- Protective gloves.
- Steel-toed, rubber-soled footwear.
- Safety glasses or goggles.
- High-visibility vests
- Fall protection harnesses

https://www.buff.com/safety/solar-panel-installers/

Providing workers with the right PPE is essential for maintaining a safe and secure job site, reducing the risk of injury.

Project Information

115/34.5kV Solar Plant & Substation

Substation Overview

- Power enters the substation via high-voltage transmission lines, typically around 115 kV. Transformers within the substation then step this voltage down to a lower level, such as 34.5 kV, for distribution. The power flows through switchgear, which serves to manage and protect the system in case of a fault or emergency. Finally, the voltage reaches the busbars, which distribute the electricity across various outgoing lines for further delivery to the grid or local networks.

Solar Farm Overview

- Covers the key components and operation of the solar power site. It includes the types and arrangement of solar panels, how they convert sunlight into DC electricity, and the use of inverters to convert it to AC. It also explains the layout of the field for optimal sunlight exposure, potential use of tracking systems, and how the energy is transmitted to the substation for grid integration. Optional elements like energy storage may also be included.

Requirements - Deliverables

Expected Deliverables:

* Equipment sizing calculations (solar panels, inverters, etc) – Excel files
* Solar layout drawings – Bluebeam/CAD/PDF editor
* Solar panel string sizing design – Excel files
* Electrical layout drawings (substation equipment) – Bluebeam/CAD/PDF editor
* Grounding analysis and ground-grid developed with IEEE-80 – Excel files
* Additional calculations (AC, DC, lightning protection, etc.) – Excel files
*Simulation of designed substation – SIMULATION SOFTWARE – STUDENT LICENSE [ETAP/SKM/ASPEN]
* Load Flow Analysis / AC Arc Flash Study / Protection Element Analysis – SIMULATION SOFTWARE – STUDENT LICENSE [ETAP/SKM/ASPEN]
* Creation of solar/substation conceptual design-optimizing tool – Microsoft Access/TBD

Requirements - Classes

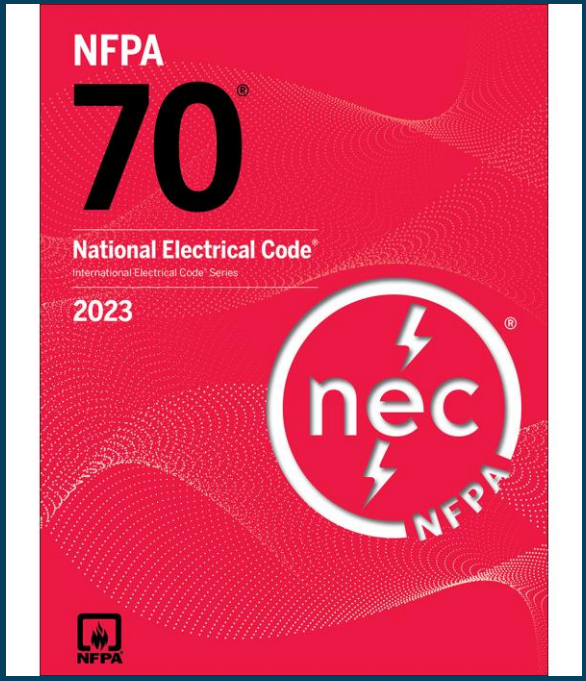
- EE 3030: Energy Systems and Power Electronics
- EE 4550: Introduction to Energy Distribution Systems
- EE 4560: Power System Analysis I
- EE 4570: Power System Analysis II
- EE 4580: Economic Systems for Electric Power Planning

Engineering Standards

- There are engineering standards that we will follow from IEEE. They are not requirements but using these standards will provide a more solid design and ensure reliability and compatibility with the rest of the power grid.
  - Some examples of standards we will follow are:
    - IEEE 485 – Sizing of Lead Acid Batteries
    - IEEE 1584 – Guide for Performing Arc-Flash Hazard calculations

Engineering Standards

- We will also follow the National Electrical Code (NEC) for our designs which will help us with our voltage drop calculations and cable sizing.



Engineering Software

AutoCAD

- Use for Drawings, Models, Documentation

Bluebeam

- Use for simple markups, document management and collaboration

ETAP

"Electrical Transient Analyzer Program"

- Use for the design, analysis, optimization, and renewable integration of electrical power systems

Problem Statement

115/34.5kV Solar Plant & Substation

Problem Statement

- 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. Our team has been tasked with designing a 60 MW solar farm and a 34.5/115 kV substation. We are expected to produce many deliverables such as drawings, calculations, layouts, and simulation results. The final product should reflect a completed design that is ready for construction.

List and description of related products

115/34.5kV Solar Plant & Substation

Product Services and Design *What is the product?*	**Unique Value Proposition** *What makes this product unique?*	**Product Advantages** *What are the things that provide a leg up?*	**Product Disadvantages** *Where might drawbacks exist?*	**User Pros** *What do users like about the product?*	**User Cons** *What do users NOT like about the product?*
 Solar Panel	This product can turn light from the sun into usable power.	This product provides a way of generating clean energy from a resource that will not be depleted.	Solar farms can take up large amounts of land. They also do not generate power at night causing a need for other forms of generation. Costly	It is better for the environment. The process for generating electricity is basic and easy to connect solar panels together.	It provides an inconsistent amount of power based on how much sunlight the panel is receiving. Takes up large amounts of space which can lead to issues with landowners.
Inverter 	A solar inverter takes the DC produced from solar panels and turns the DC into AC power used in substations or houses	This product takes a single string or multiple strings of solar panels and converts to usable AC power which is usually found in homes	Some disadvantages are that the AC waveform generated is sometimes not purely sinusoidal which can cause harmonic disturbances. They are also expensive. Specific inverters, like central inverters, can potentially cause substantial power loss if downtime occurs.	There are some types of inverters like microinverters that can improve efficiency by preventing one panel's issues from affecting the whole system. This is ideal for some panels that are under shade while others are not.	Inverters can be very costly and can be a failure point in solar generation systems. Some users have certain brands of solar inverters that are prone to fail more easily, and it may take weeks to replace. This can cause

					customers to miss out on energy cost savings.
Combiner box 	Multifunction: PV array input with first class combination, Quickly cut off circuit, anti-thunder protection, anti-reverse, overload	Pre-wired cable and isolates solar panel strings safely and efficiently like-up Excellent build quality and simple installation like-up Can combine PV string with different wattage outputs like-up Comes with specific rated fuse, surge protective device, and air circuit breaker	Cannot support mounting flat on RV roofs with cable entry points facing away from direction of travel Like-down Additional fuse holder cannot be added Like-down Not UL rated, which could be a concern for some customers	Over load protection function. High quality wires. Metal box with a lock. Waterproof class: IP65. Durable metal box makes it much more suitable for outside use and installation. It has a longer lasting time than the PVC plastic solar combiner box.	The labeled + & - are incorrectly labeled, so extra attention must be paid during installation. The product can not support mounting flat on RV roofs with cable entry points facing away from the direction of travel, and additional fuse holder cannot be added. The product stops sometimes.

Description of market gap

115/34.5kV Solar Plant & Substation

Description of market gap

Current Shortcomings:

- Limited Clean Energy: Lacking sufficient renewable energy sources to meet growing demands.
- Outdated Technology: Existing solar farms use older technologies that aren't as efficient or effective.

Our 60MW Solar Farm Solution

- Adding Generation: Increasing the available clean energy supply to meet growing demands.
- Advanced Technology: Utilizes the latest solar technology to ensure maximum efficiency and reliability.

Immediate Benefits

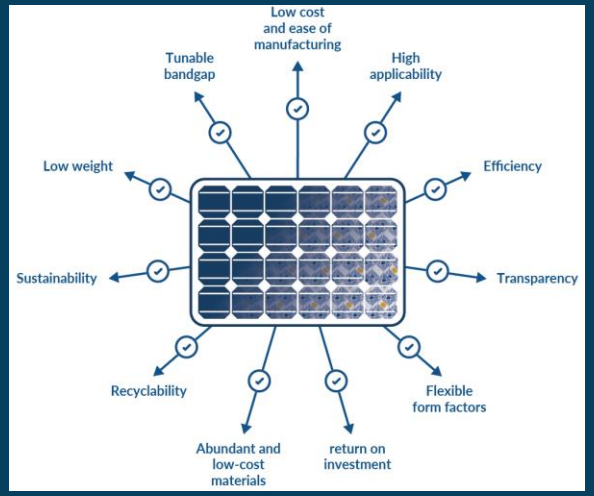
- Meet Energy Needs: Directly addresses the shortfall in renewable energy availability.
- Economic and Environmental Gains: Reduces reliance on costly non-renewable energy and cuts down carbon emissions, promoting a greener economy.

New ideas generated by product research

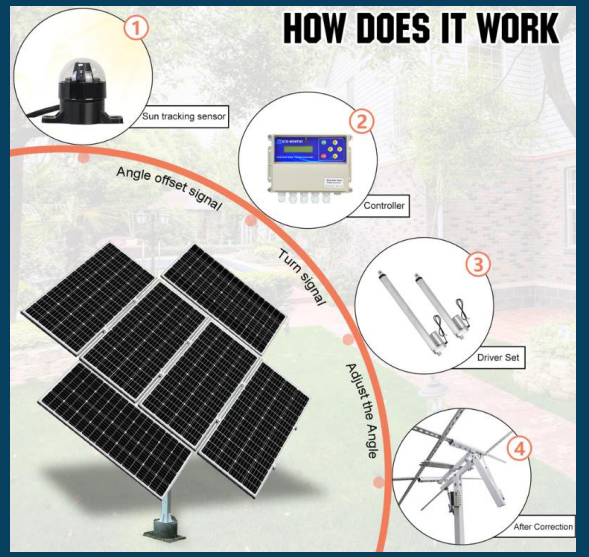
115/34.5kV Solar Plant & Substation

Bifacial Solar panels

Perovskite Solar Cells



Advanced Solar Tracking Systems



Conclusions

115/34.5kV Solar Plant & Substation

Conclusions

- Clean Energy: Our 60 MW solar farm and substation will meet the needs for more renewable energy
- Latest Technology: We will be using the newest technology to make sure our solar farm is highly efficient and performs well for many years in the future
- Great for the environment: Our solar farm provides a source of clean energy to the grid, promoting environmental stewardship and aiming to reduce carbon emissions

Questions

Thank You