SOLAR PLANT & SUBSTATION

60MW Solar Power Plant & 115/34.5kV Substation Design

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Client: Black & Veatch *Client Contacts: Cole Beaulieu, Patrick Kester, Emily Neumann* *Advisor: Dr. Ajjarapu, Venkataramana*

Problem Statement

Problem: Provide clean energy for a grid shifting towards renewables to decrease its dependence on fossil fuels.

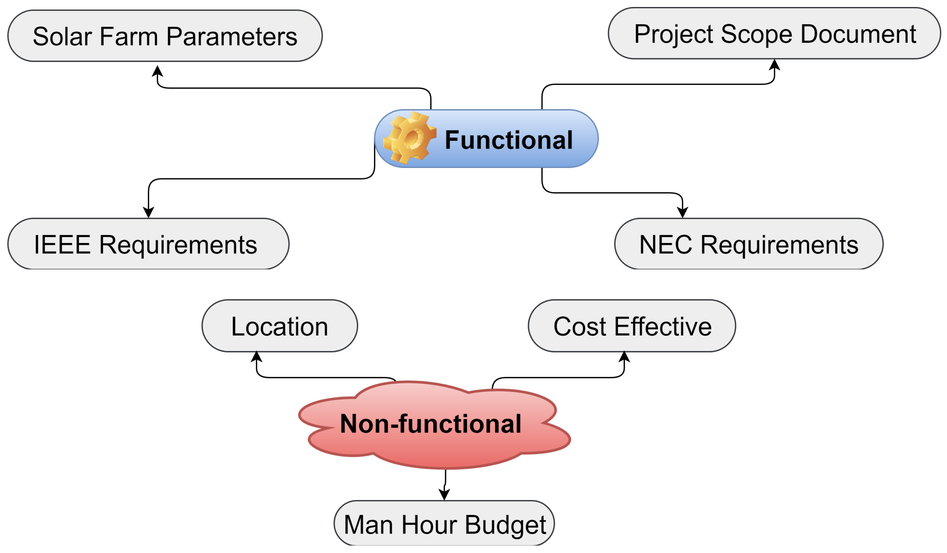
Solution: Design a 60 MW solar power plant and a 115kV/34.5kV substation to connect the plant to the grid.

Design Approach

The following is our approach from the design of solar plant to substation protection and controls.

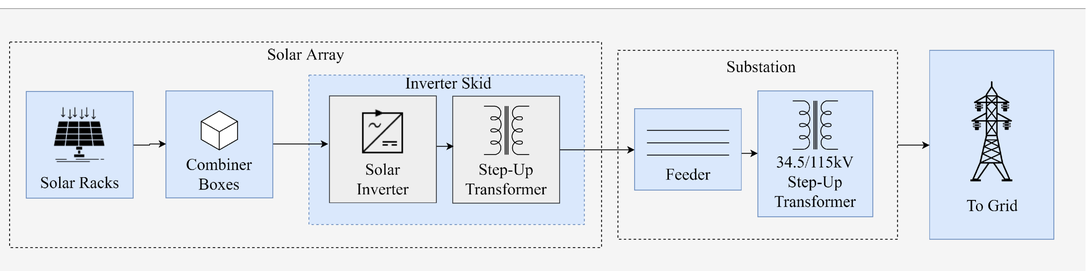
1. Scout several locations and evaluate them based on requirements.
2. Perform a series of calculations to determine solar parameters.
3. Create layout design of solar power plant based on parameters and ensure design meets NEC requirements.
4. Create substation protection & controls schematics based on the project scope document and the key protection diagram.
5. Perform grounding calculations based on IEEE document.

Design Requirements

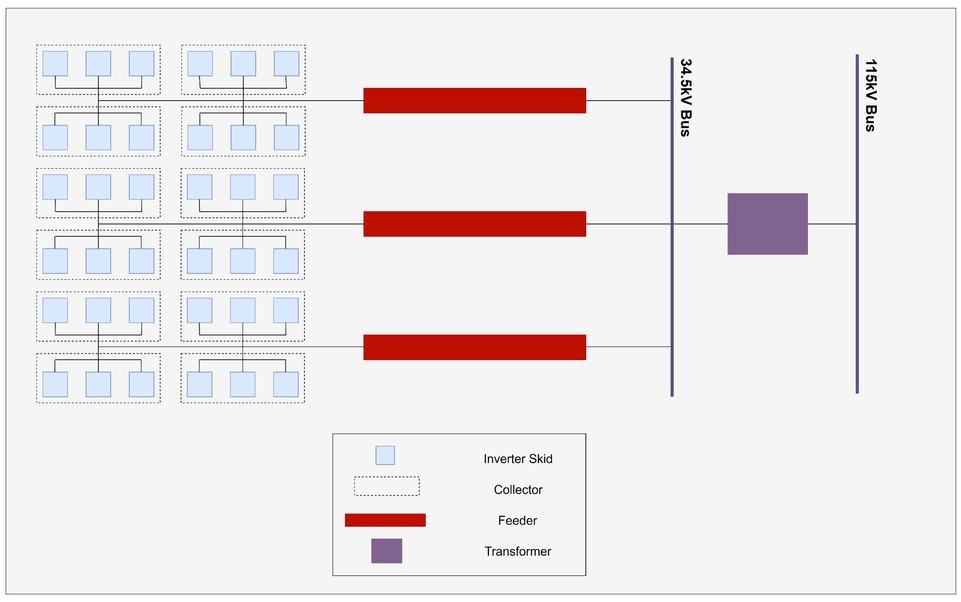


System Block Diagrams

The diagram below shows power flow of the overall system from solar power generation to grid transmission. The solar racks generate DC power, which is then combined by the combiner boxes and converted into AC power by the inverter. The voltage is then stepped-up by a transformer and fed into the substation, which steps up the voltage again before sending it to the grid.

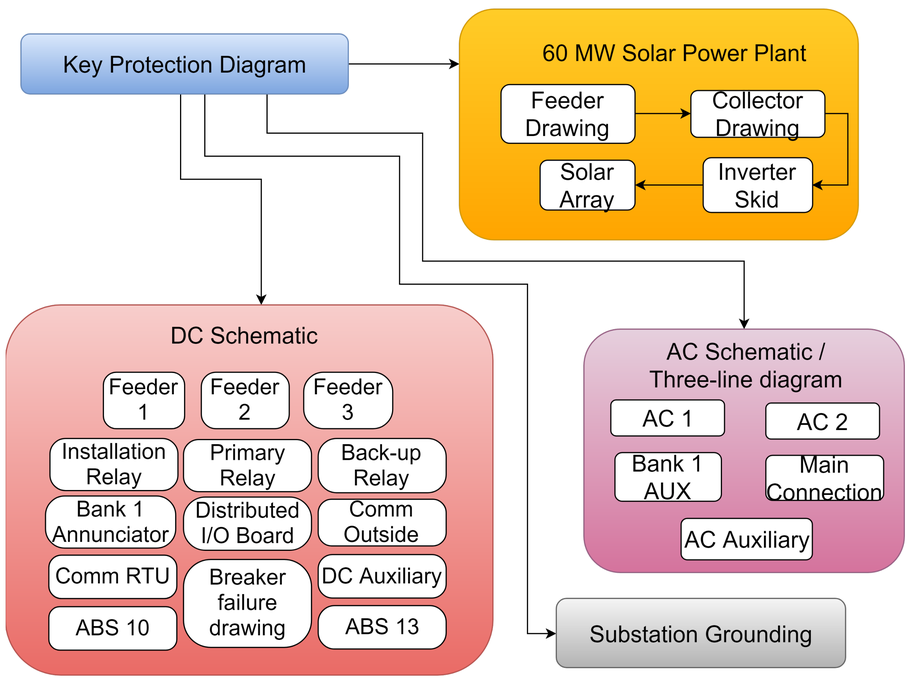


Below is a diagram showing how each inverter skid is connected to the substation through the feeders. Each inverter skid corresponds to one solar array. One collector contains three inverter skids.



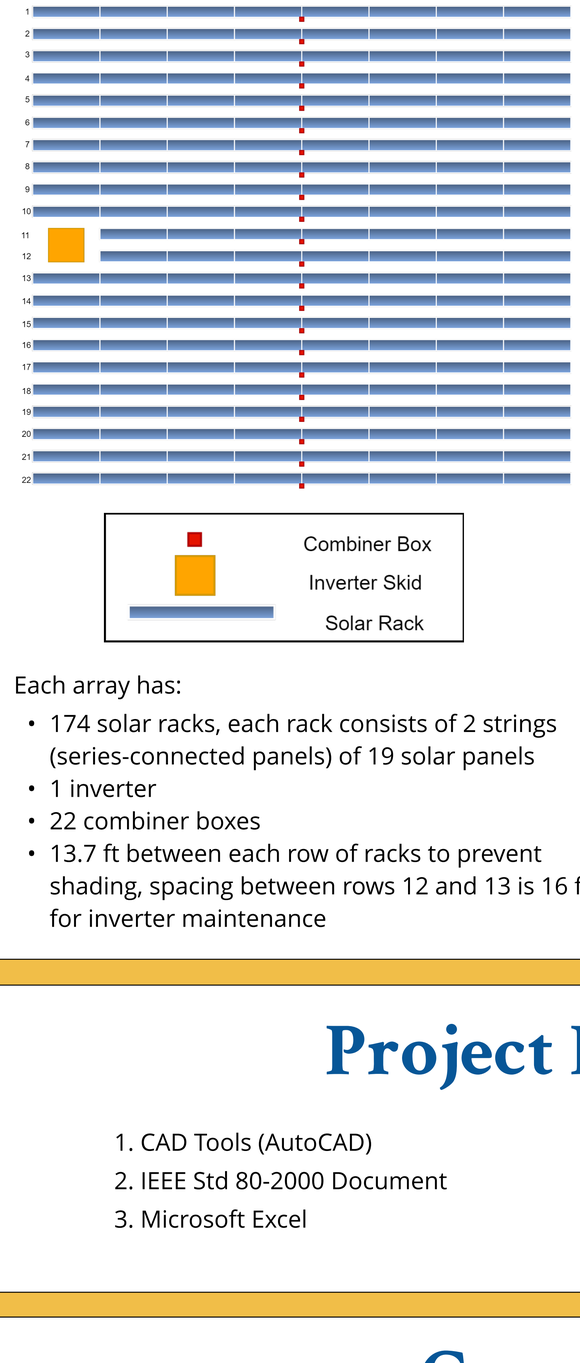
Protection & Controls Design Hierarchy

The diagram below shows the list of schematics that are included in the scope of our project. All drawings are based on the key protection diagram and project scope document.



Solar Plant Design and Simulation

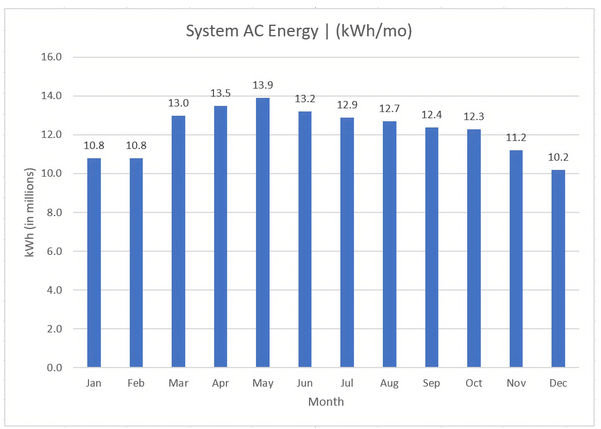
The diagram below is the layout of a single solar array. Our solar plant is made up of 36 arrays in a 6x6 arrangement with a 16 ft spacing between each array.



Each array has:

- 174 solar racks, each rack consists of 2 strings (series-connected panels) of 19 solar panels
- 1 inverter
- 22 combiner boxes
- 13.7 ft between each row of racks to prevent shading, spacing between rows 12 and 13 is 16 ft for inverter maintenance

The graph below shows the expected energy production by the solar plant in kWh per month that was simulated using NREL SAM. The location that was chosen for the project is Estancia, New Mexico.



Solar Plant Cost		
Components	**Count**	Cost (million $)
Panels	238032	48.558528
Combiner Boxes	792	1.01420352
Inverters and Step-Up	36	1.956717
Land (Acres)	243.1172708	0.195
	Total Cost	51.72444852

The cost of the solar power plant can be seen in the table above, but it does not include labor costs. The count is the number of components calculated during the design of the project.

Based on similar projects, we estimated the substation cost to be $22 million. With this, the total cost of the project comes up to $73.7 million.

Project Resources

1. CAD Tools (AutoCAD)
2. IEEE Std 80-2000 Document
3. Microsoft Excel
4. National Electrical Code (NEC) Document
5. National Renewable Energy Lab System Advisor Model (NREL SAM)

Conclusion

This project design is successful because it provides renewable energy to the grid in a cost efficient manner. The implementation of this project would make the grid less dependent on fossil fuels, and thus decrease the effect of greenhouse gases. Future work can include adaptation of the project by the client.