115kV/ 34.5kV Solar Power Plant & Substation Design Project

Team: SDMAY21-37
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Client: Black & Veatch

Project Statement:

This project sets out to design a solar plant and power substation for Black & Veatch. This project is very important because as the regulations increase for the use of renewable energy, Black & Veatch must continue to meet the demands of those regulations. This is largely due to the rapid climate change that the planet is currently experiencing.

Solution:

Under the guidance of Black & Veatch along with our Iowa State mentor, our team designed a 60MW solar plant and a 115kV/ 34.5kV distribution substation.

Non-functional Requirements:

- Land should be flat and cheap
- Area chosen should show high irradiance
- Land use should be maximized
- Must return investment in 10 years
- Substation should be able to provide power to nearby communities

Functional Requirements:

- Operate at environmental conditions provided
- Power rating at the solar farm of 60 MW
- Minimize voltage drop across solar plant
- Adhere to IEEE, NEC, and ANSI standards
- Safely ground the entirety of the substation
- Keep the trench cabling capacity at 40%
- Establish over-current/fault protection system
- Calculate overall DC and AC loads

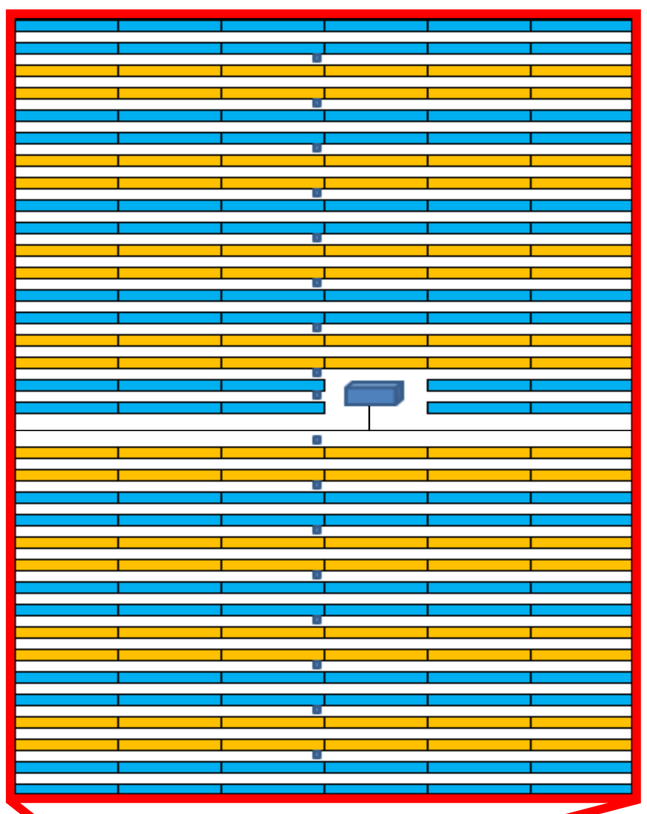
Components and Software:

Component List (Solar Plant):
Solar Panels (146,400)
Inverters (15)
Combiner Boxes (247)

Component List (Substation):
Current Transformers (28)
115kV/ 34.5kV Voltage Transformer (1)
Disconnect Switches (11)
Circuit Breakers (5)
Trenching Structure (a lot)
Cables (a lot)

Software:
Microsoft Excel
BlueBeam Revu Studio
Microsoft Teams
https://bsp.enersys.com/

Diagram 1: Single Array Layout



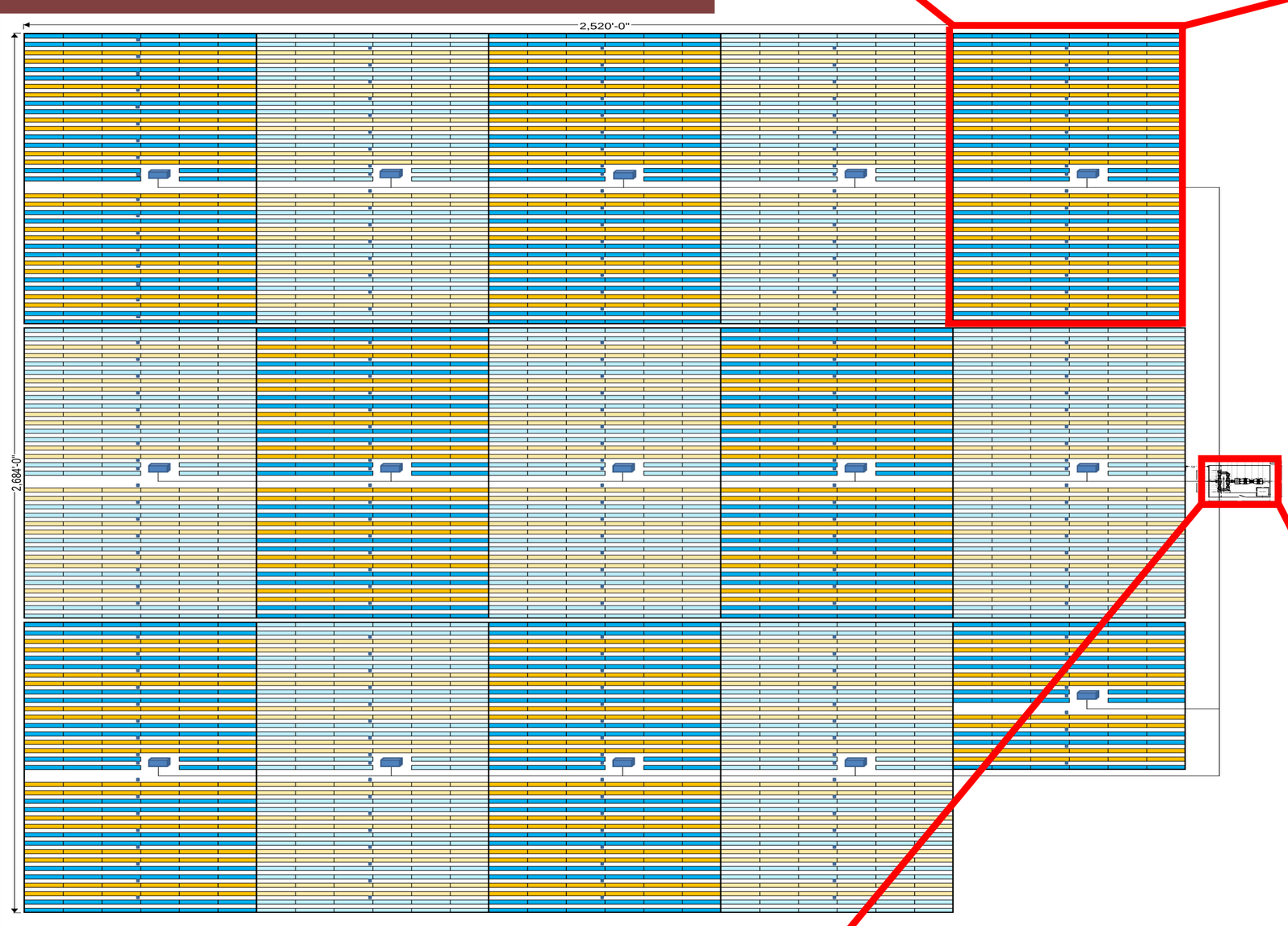


Diagram 2: Overall Layout of Solar Plant and Substation

Diagram 3: Overall Substation Plan View

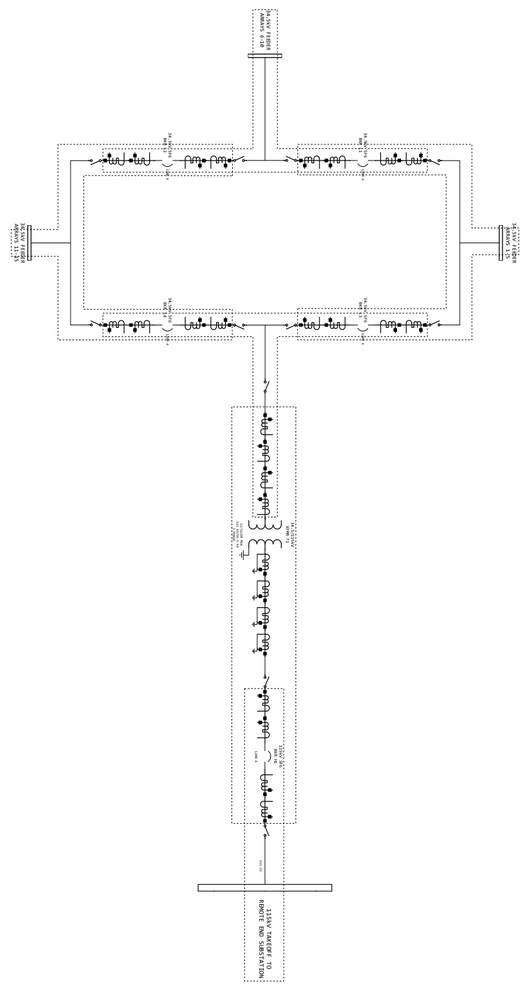


Diagram 4: One-Line Diagram for Substation

Progression:

- Component Selection
- Array Parameter
- Plant Design/Layout
- Voltage Drop Calculation
- Economic Analysis
- Substation Layout
- Trench Fill Tool
- Grounding Calculations
- Bus Calculations
- DC Battery Calculations
- Overcurrent/Fault Protections
- AC Load Calculations

Challenges:

- Project management/ team coordination
- Optimization of grounding calculations
- Revu Studio only supports single person at one time
- Ability to reach performance target under constraints
- Reading through code

Risks and Risk Management:

- Effective fault
- protection
- Proper grounding
- Overcurrent
- compensation

Engineering Constraints:

- Physical testing
- Estimated pricing of components
- Time to complete project
- Background knowledge of the project was slim

Testing:

All testing was done through comparison with historical values and similar projects which have been completed by Black & Veatch. Additionally, we used IEEE, NEC, and ANSI standards to evaluate whether or not our designs matched what is commonly seen in a project like this one.

Economic Evaluation:

Overall cost of solar plant = $106,020,000
Overall cost of substation = $7,000,000
O+M a year for solar plant = $780,000
O+M a year for substation = $220,000
Yearly Revenue = $12,989,088
Profit after 10 Years = $17,386,929.47
Expected life cycle = 20-25 years