115/34.5 kV Solar Power Plant & Substation

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BLACK & VEATCH

Introduction

Due to increasing demand of renewable energy by utilities, we as a team from Iowa State University, under Black & Veatch, will be working on the design project. The project consists of two parts : 60 MW Solar Power Plant and 115/34.5kV Substation Design. Last semester, we have worked on the 60 MW Solar Power Plant. This semester, we are working on the 115/34.5kV Substation design project. Our project location is located on the border of New Mexico and Texas, northeast of Lovington, NM.

Introduction

User

- The electricity generated from the solar power plant will benefit the people of New Mexico, as well as Texas, as the substation will be connected to the nearest main power grid (SSP Interconnection).

For example,

- Residential consumers : Homes and apartments for lighting, heating and power appliances.
- Commercial and Industrial Consumers: Business, factories, offices and other commercial entities to operate their equipment, machinery and other facilities.
- Government facilities: Public buildings,schools, hospitals, and other government institution, reducing reliance on the fossils fuels and promoting sustainability.

Project Impact

User:

Cost savings: reduced electricity cost due to cheaper alternative.
Reliability: Reliable energy supply, reduced reliance on the main grid distribution.
Clean energy access: Reduce carbon footprint and promote sustainability.

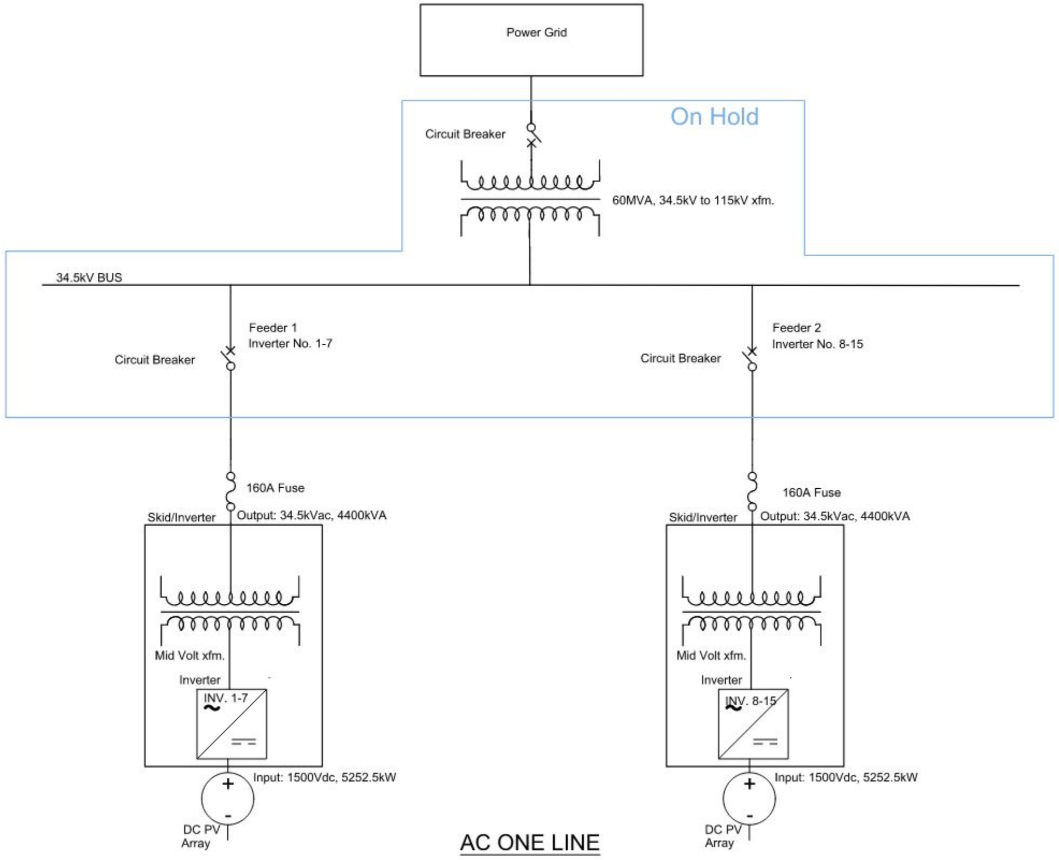
Society:

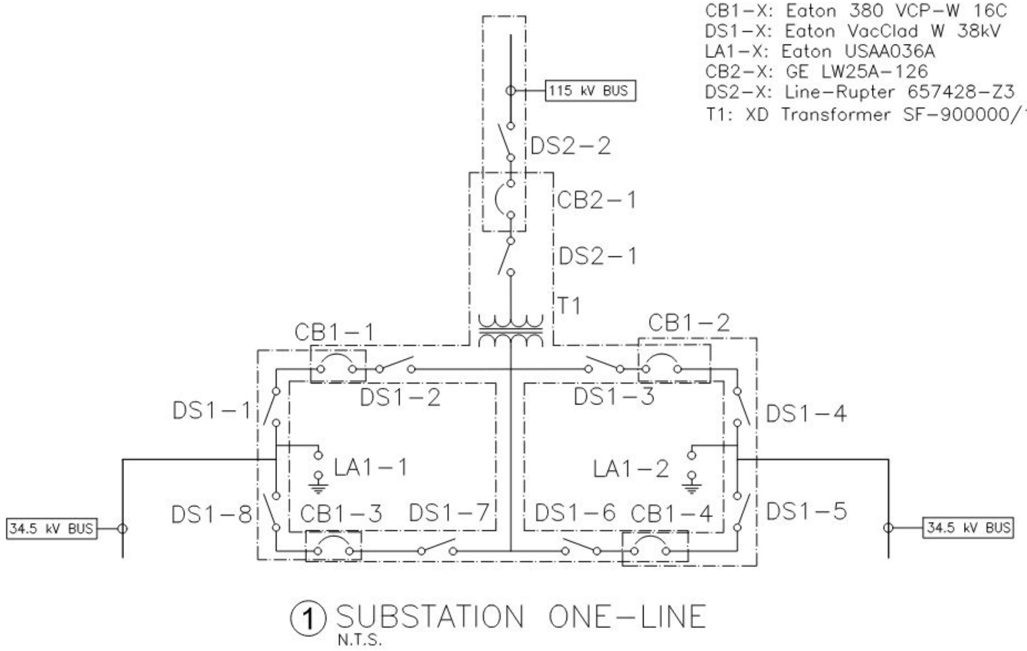
Job opportunities: Construction, operation, and maintenance, benefiting local economies.
Infrastructure development: Enhance region's infrastructure, attract further investments and development.
Improved health: Mitigate air and water pollution, improve public health and quality of life.

Humanity:

Climate change mitigation: Renewable energy sources contribute to global efforts on reducing greenhouse gas emissions.
Energy access: Provides energy security to the region to avoid energy supply disruption to happen.

Detailed Design





CB1-X: Eaton 380 VCP-W 16C — SEE SS110 FOR MORE INFO
DS1-X: Eaton VacClad W 38kV — SEE SS112 FOR MORE INFO
LA1-X: Eaton USAA036A — SEE SS114 FOR MORE INFO
CB2-X: GE LW25A-126 — SEE SS111 FOR MORE INFO
DS2-X: Line-Rupter 657428-Z3 — SEE SS113 FOR MORE INFO
T1: XD Transformer SF-900000/115 — SEE SS115 FOR MORE INFO

Detailed Design

String Size

Location Dependent	Min Temp	-40	C
Datasheet (STC)	Voc	50.2	V
Datasheet (STC)	Ref temp	25	C
Datasheet	Temp Coeff of Voc	-0.0029	/C
	Temp delta	-65	
	temp correction	1.19	
	V0c corrected	59.6627	
Confirm possible with Panel type chosen; Designer Choice: 600, 1000, 1500, 2000V	string voltage	1500	V
	String size	25.14133	
	string size	25	
	Actual String Voltage	1491.6	
	Input Information =		

Electrical Rack Size

Designer Choice		portrait or Landscape	
Datasheet	Module width	3.72	ft
Datasheet	module height	7.474	ft
Designer Choice	Rack width	25	modules
Designer Choice	Rack height	1	modules
	Modules per rack		
	Rack width	93	ft
	Rack height	7.474	ft

CB capacity

Datasheet (STC)	mod/string Isc	13.89	A
NEC secti	multiplier	1.25	
	nom Isc	17.3625	
Irr.	multiplier	1.25	
	max Isc	21.70312	A
Choice: 200, 400A etc.	allowed current	350	A
	is this disconnect A?		
	strings per CB	16.12670	
	Round down:	16	
	racks per CB	16	

Array Design

Designer Choice	Racks per row	16	
Designer Choice	rows per Array	24	
Designer Choice	Racks removed	2	
	Total Racks/Array	382	
	Total modules	9550	
Datasheet (STC)	module capacity	550	W
	dc capacity	5252.5	kW
Designer Choice	inverter capacity	4000	kW
		4	MVA
: Industry standard 1.3	ILR	1.313125	

Array Size

Designer Choice	tilt	35	
	table height proj	6.122342	ft
Designer Choice	row space	10	ft
	pitch	16.12234	ft
	Space for Inverter Maintenance	35	ft
	Array height	386.9362	ft
	Array width	1488	ft
	Ground Coverage Ratio	0.463580	

Detailed Design

	Pmax (W)	Vmp (V)	Imp (A)	Voc (V)	Isc (A)	Mod Eff (%)
PVX-Y-Z.Z	550	41.90	13.13	50.20	13.89	21.29

Model No. ZXM7-SHDB144

	Vmax (V)	Input #	Imax in (A)	Imax out (A)
CBX-Y	1500	16	30	350

Model No. BHTZ-16/1

	INPUT (DC)			OUTPUT (AC)			
	PVmax (kWp)	DC Volt Range (V)	DC Inputs	Snom (kVA)	Smax (kVA)	Output Freq (Hz)	Inv Eff (%)
INV-X	2 x 3200	935-1500	24	4000	4400	60	98.8

Model No. PVS980-MWS-4000kVA-K

	Vmax (kV rms)	Isc (kA rms)	Curr Rating (A rms)	Model No.	
CB1-X	38	16	1600	380 VCP-W 16C	SEE SS110 FOR MORE INFO
CB2-X	126	40	3150	LW25A-126	SEE SS111 FOR MORE INFO

	Vmax (kV rms)	Isc (kA rms)	Curr Rating (A rms)	Model No.	
DS1-X	38	16	2000	VacClad W 38kV	SEE SS112 FOR MORE INFO
DS2-X	121	40	2000	657428-Z3	SEE SS113 FOR MORE INFO

	Vnom (kV)	Vmax (kV)	Isc (kA rms)	Model No.	
LA1-X	36	217	63	USAA036A	SEE SS114 FOR MORE INFO

	LOW SIDE		HIGH SIDE				
	Vnom (kV)	Inom (kA)	Vnom (kV)	Inom (A)	Rating (MVA)	Model No.	
T1	34.5	1.5	115	451.8	90	SF-900000/115	SEE SS115 FOR MORE INFO

Work Progress

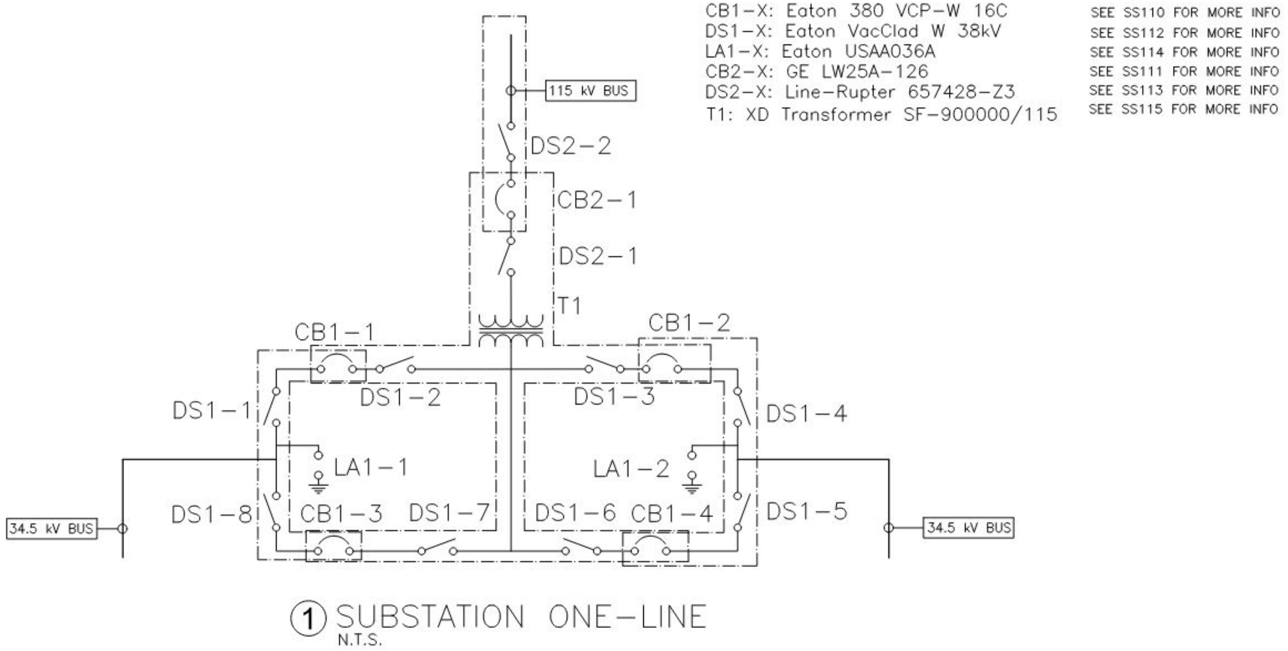
Four main areas of work progress thus far:

1. Equipment selection and research to meet specifications and fit within budget
2. AutoCAD for drawing of design components and production of deliverables
3. ETAP for power flow simulation of the PV farm and the substation
4. Calculation documents provided by Black & Veatch

Work Progress

AutoCAD Deliverables:

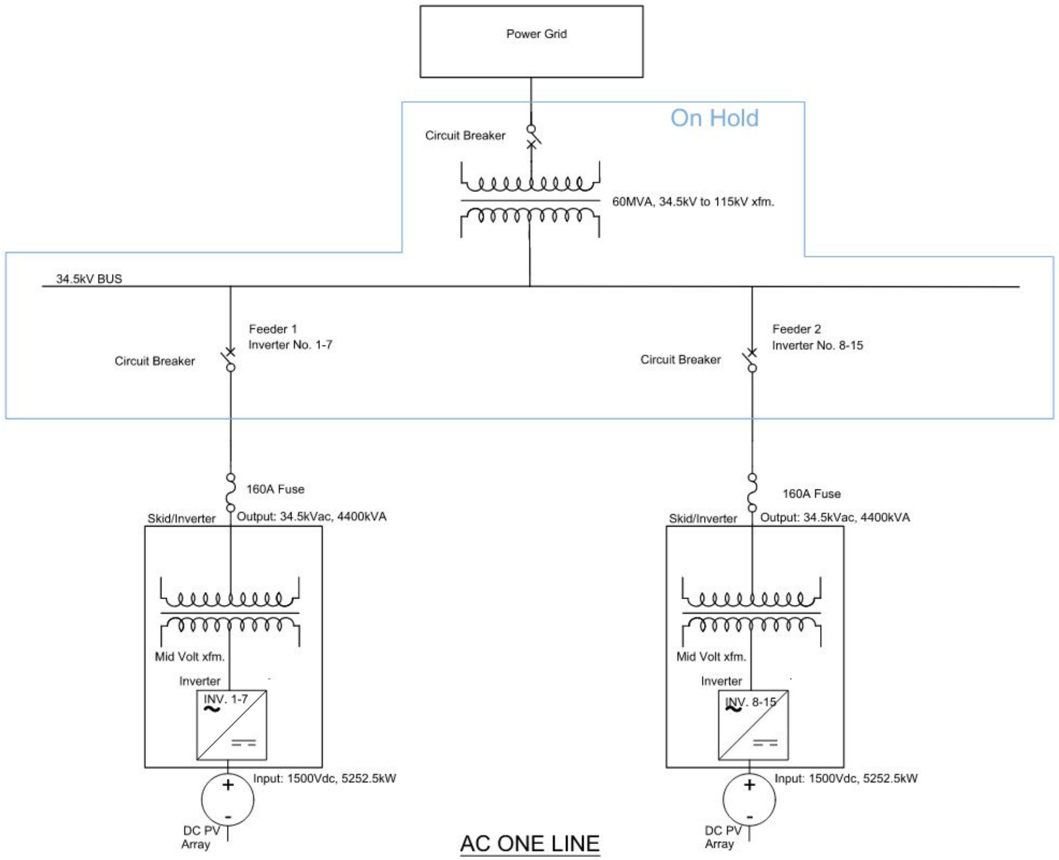
- This semester has been solely focused on substation design
- Drawing progress thus far has included site plans, substation one-line diagram, and substation modeling
- A majority of the remaining work includes detailing of current drawings and more detailed views of the drawings already included on the sheets

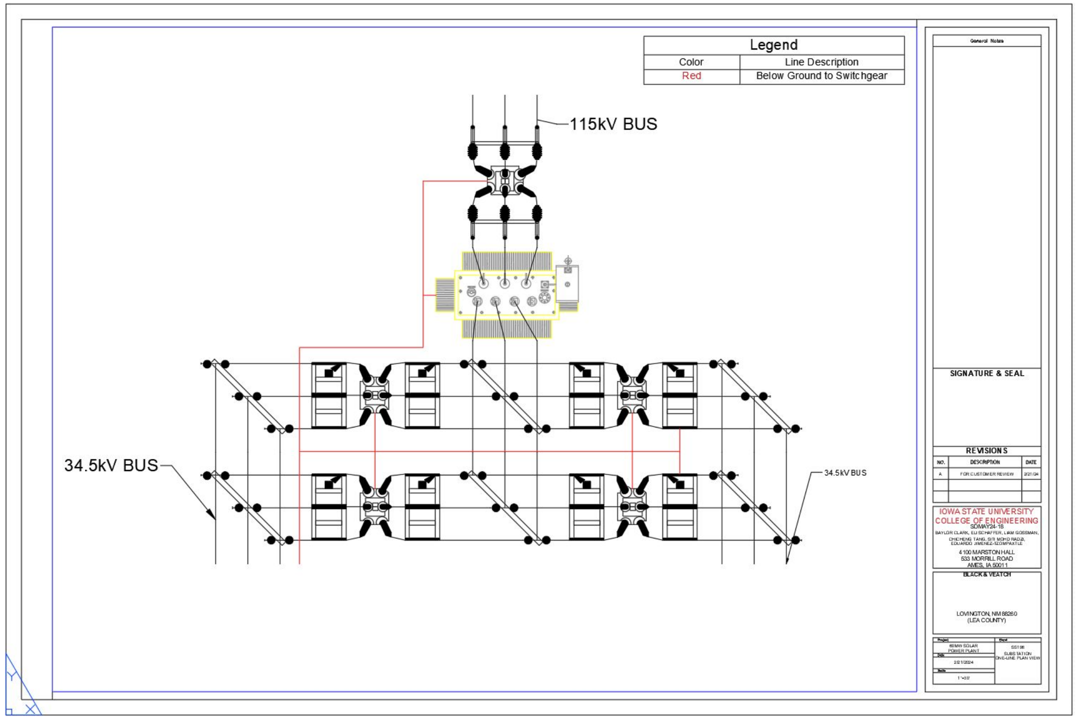


Substation One-line Diagram:

- Provides the overall electrical layout of substation to be feed by the solar farm
- Design and drawing of the one-line has been fully completed and only remaining tasks is to detail the equipment used and provide necessary details and specifications

Work Progress





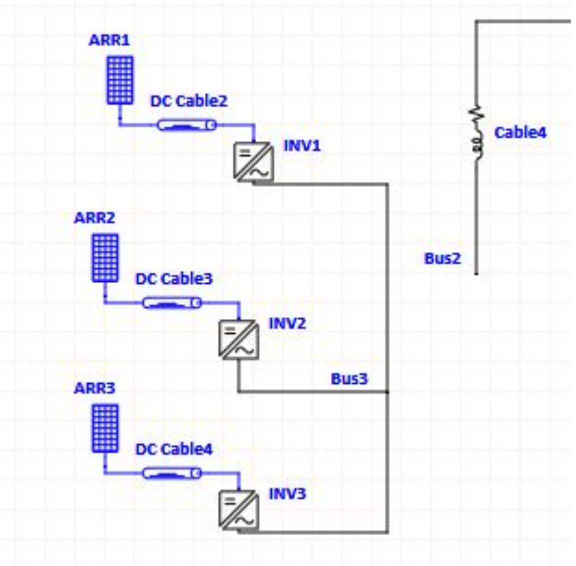
- Update to the AC one-line diagram to meet most updated design iteration

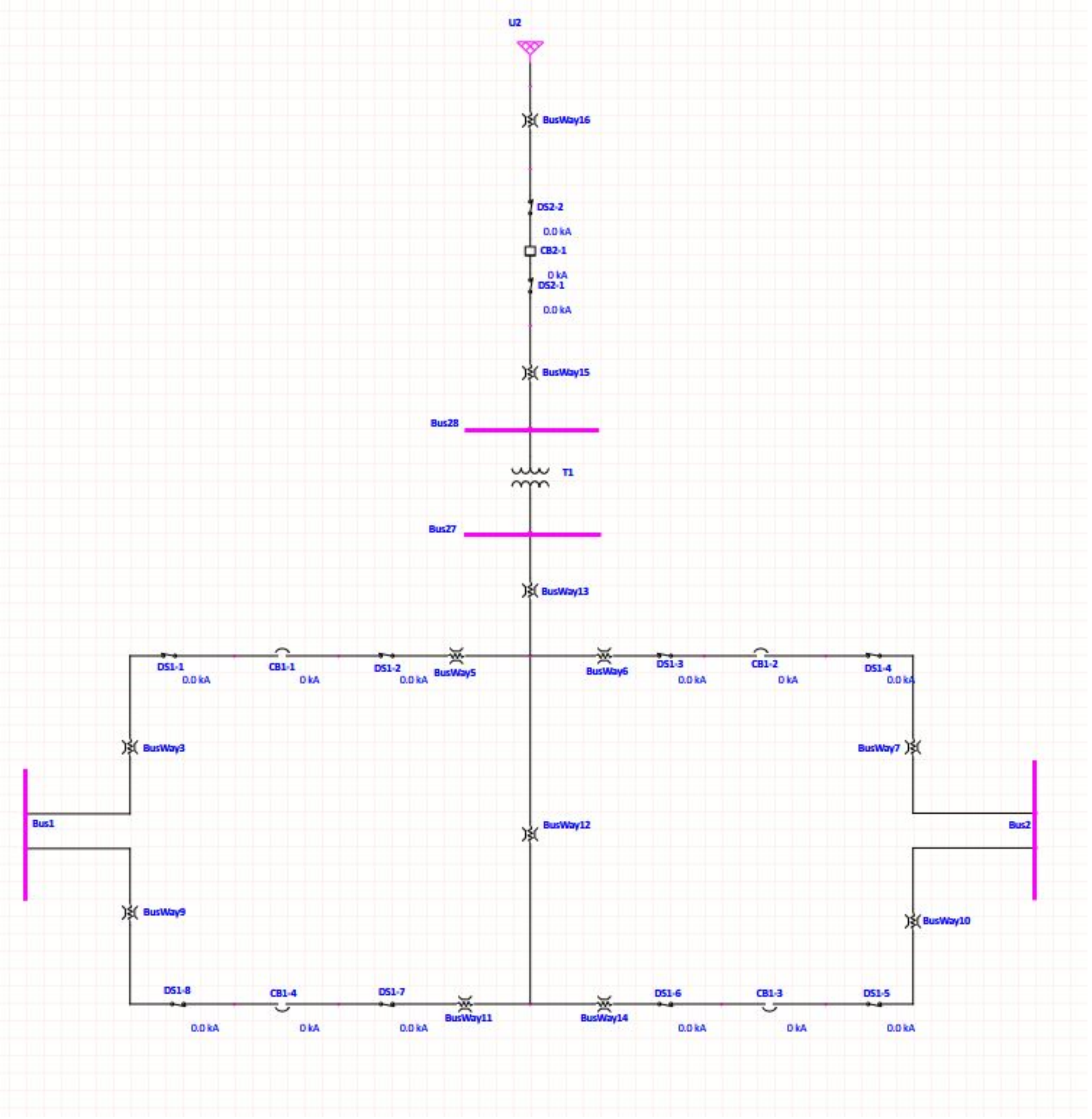
- Three line substation model to show interconnections and crucial components in substation design

Work Progress

ETAP:

- ETAP was the recommended power flow simulation software by Black & Veatch.
- As of now, our progress has primarily revolved around laying out the components.
- Moving forward, our focus shifts towards verifying all specifications for accuracy.





Work Progress

Calculations:

- Black & Veatch provided documents and excels files to help aid in certain required calculations.
- Much of the progress up to this point has only included entering information we have already determined.
- A majority of the information comes from specific equipment and implementation.
- Over the next month the group will continue to use these tools to accurately calculate electrical quantities.

Fall 2023 for Solar Power Plant

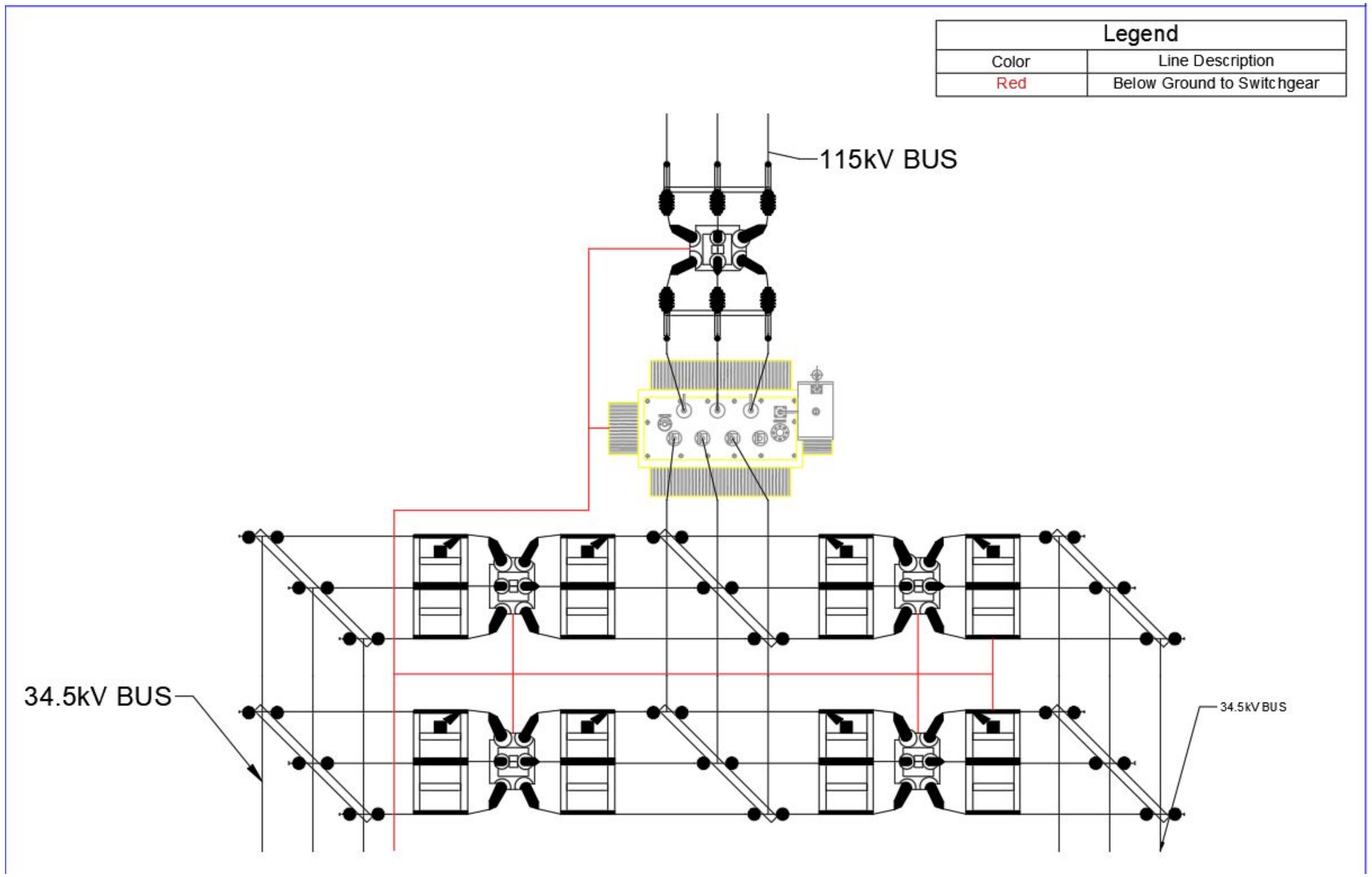
- Array Parameter Tools
- Voltage Drop Calculation
- Cost Analysis

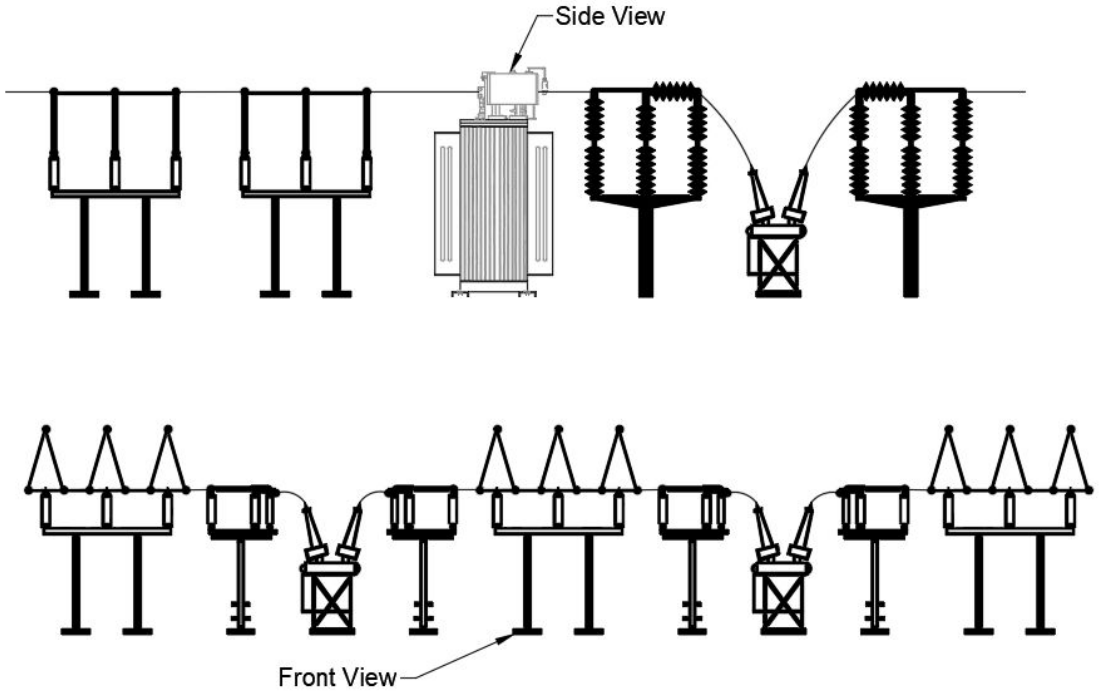
Spring 2024 for Substation

- AC Load Calculation
- DC Load & Battery Sizing
- Grounding Calculation
  - Uniform soil resistivity
  - Minimum conductor sizing
  - Tolerable and maximum step and touch voltage
- Bus Calculation
  - Ampacity calculation
  - Bus force calculation
  - Minimum allowable span
- Cost Analysis

Current Design

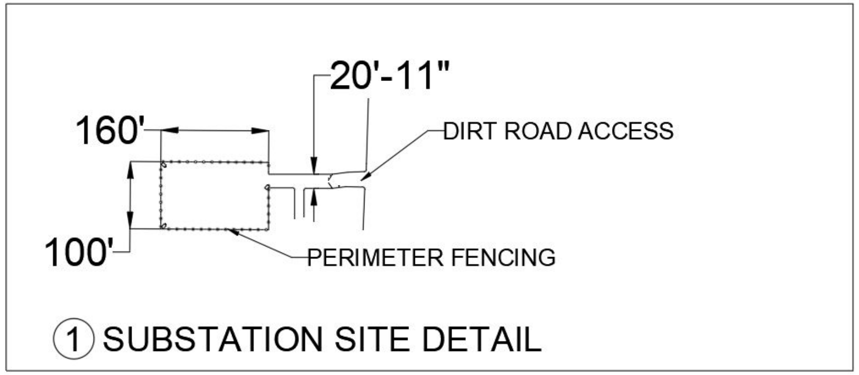
1. Ringbus Configuration for a reliable source of power if a circuit breaker needs maintenance

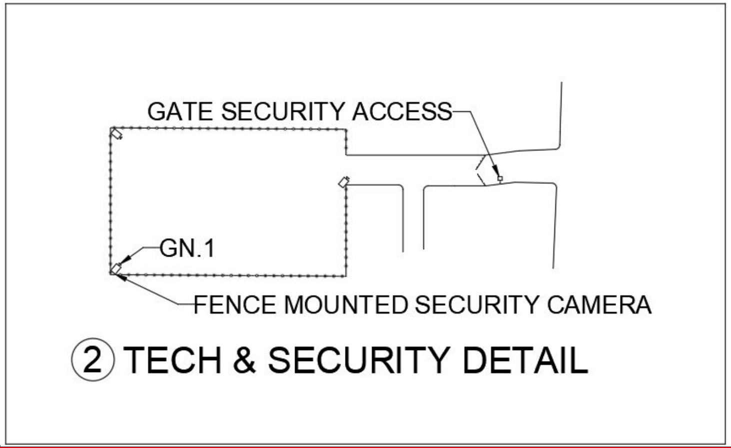


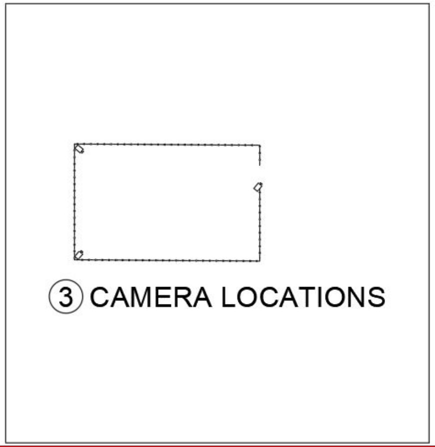


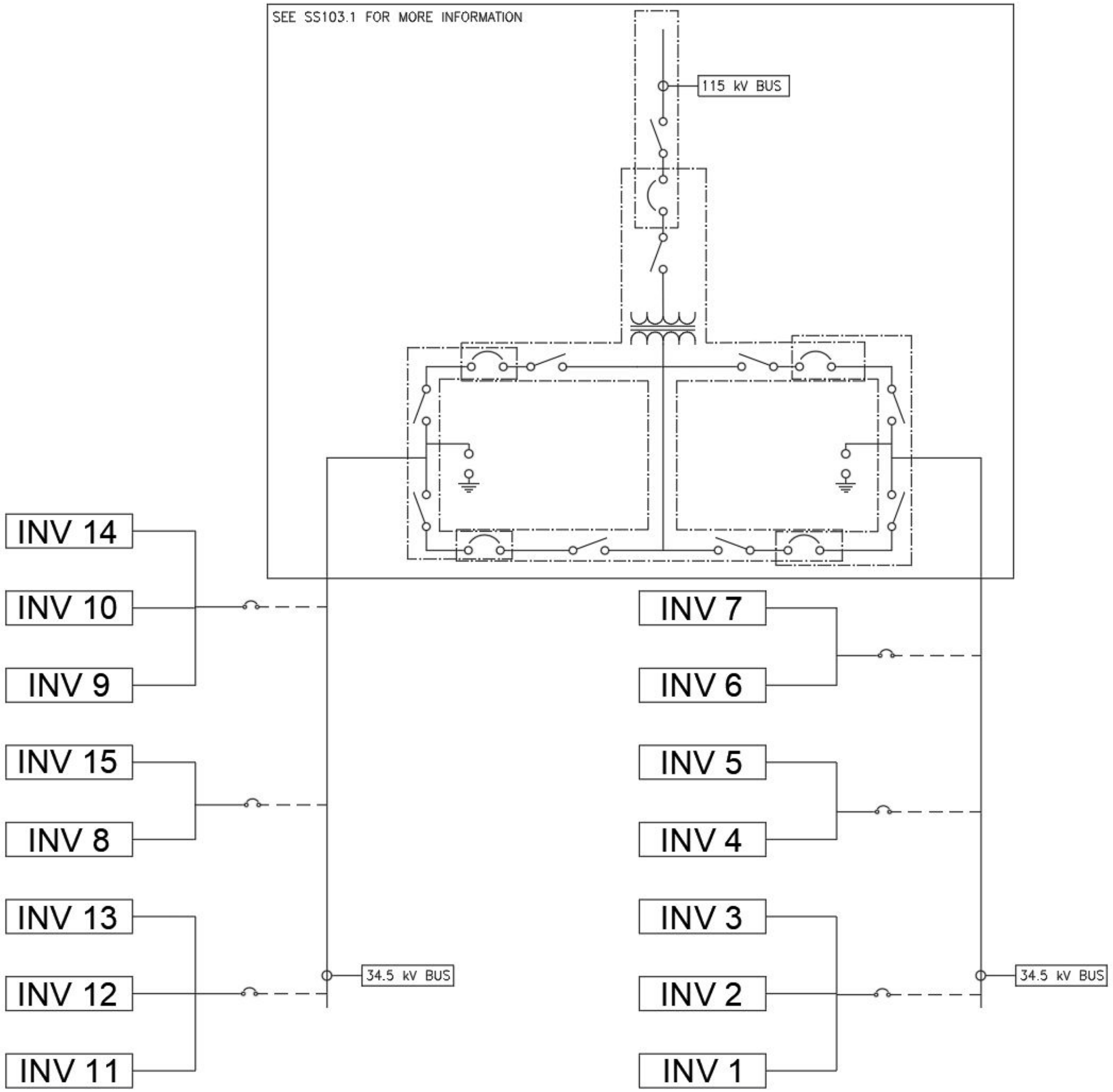
Current Design

1. The size will be 100 ft by 160 ft area with security fencing and a gate around for safety with cameras around the perimeter for security









Challenges and Solutions

- We have faced challenges finding relevant and compatible parts for our designs. This has forced us to dedicate more research and calculation time towards component selection
- Another challenge is scheduling, as we must meet clients and faculty consistently even when not convenient. We have increased our internal and external communications in order to maintain constant connection with every party involved.
- ETAP and AutoCAD have also posed challenges, both with access and organization. We have created detailed filing conventions to avoid confusion as well as working ahead to fix issues before they cause problems.

Conclusions

- **Progress of the Project**
  - Component selection
    - Solar Panel
    - Inverter
    - Transformer
    - Protection Component (Switch, Circuit Breaker)
    - Measurement Component(Current Transformer(CT) , PT(Potential Transformer))
  - Overall site plan
    - Solar Panel arrange
    - Substation Design
  - One line diagram
    - AC one line diagram
    - DC one line diagram
  - Modeling (Part)
    - ETAP (Simulation)
    - Excel (Grounding calculation)

- **Plan for rest semester**
  - Modeling
    - ETPA (Simulation)
    - Excel (Calculation)
  - Design Detail
    - AutoCAD Diagram
    - Summarize simulation and calculation result
    - Optimize the design as necessary based on simulation and calculation result
  - Final Presentation