E 491 – sdmay19-26 115kV / 34.5kV SOLAR POWER PLANT/SUBSTATION DESIGN PROJECT

Week 7 Report

Monday (10/15/2018) – Sunday (10/21/2018)

Client: Black & Veatch

Advisor: Venkataramana Ajjarapu Team Email: sdmay19-26@jastate.edu

Team Members:

Katayi Katanga – Communication Leader Nur Shuazlan – Meeting Scribe Yao Cheah – Website Manager #1 Ahmed Sobi – Team Leader/Layout Designer #1 Chufu Zhou – Website Manager #2/Layout Designer #2 Tam Nguyen – Report Manager

Weekly Summary:

This week we had a meeting with our client and advisor, and we talked about voltage drop calculations, ground coverage ratio, final solar layout, collector, and feeder. Then, we kept the same groups to continue to work on array wiring diagram, conductor sizing and type, voltage drop calculations, collector AutoCAD and parameters calculation, and feeder drawing.

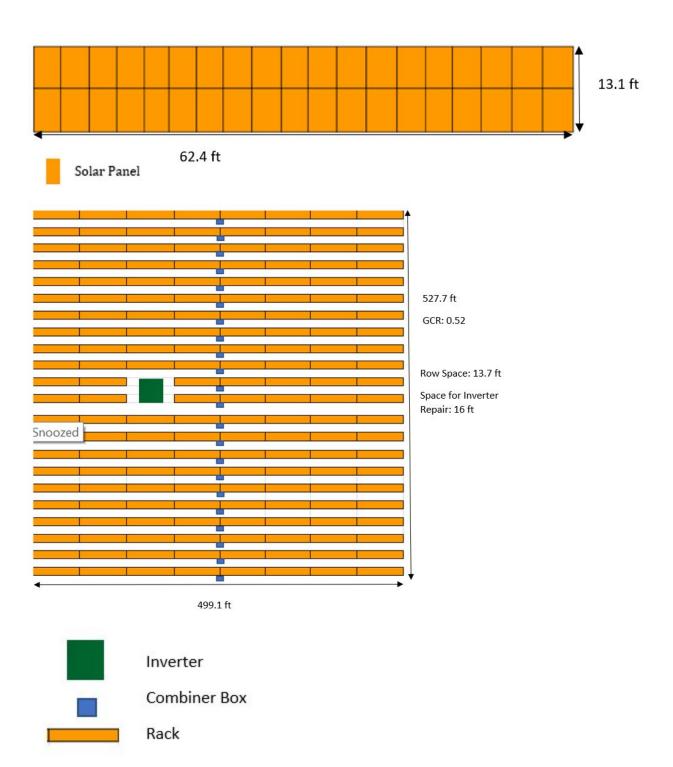
Summary of Client/Advisor Meeting:

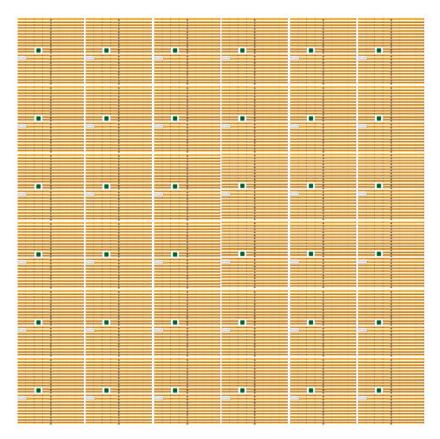
- YJ did safety moment.
- First, we talked about voltage drop calculation. Then, we figure out the value of power per rack that we got from the template does not match the calculation from the array parameter tool. Therefore, we still need to work on final plant layout and voltage drop calculation.
- Second, we talked about ground coverage ratio
 Using the supplementary software provided, students design the layout and ground Coverage ratio by given:

Row space = height of rack + tan(tilt angle) = 13.65 ft

Pitch = height of rack + row space

GCR = height of rack/pitch = 0.52





- Lastly, we talked about Collector and Feeder about what we researched last week. Then, the client wanted us to start working on design our own collector and feeder by AutoCAD.

Past Week Accomplishments:

Katayi and Nur:-

- They updated the voltage drop calculations across the cables from the solar panels to the combiner boxes and combiner boxes to the inverter using a template provided by the client. The pictures below are the results.

DCB	Strings per Harness	IMP for circuit	Rack Harness Length	Rack Harness wire size	Rack Harness resistance	Rack Harness resistance	Voltage Drop of Harness
DCB#-##	per rack	Amp	feet	AWG	Ohm/kft	Ohm	Volts
DCB1-01	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB1-02	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB1-03	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB1-04	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB1-05	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB1-06	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB1-07	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB1-08	2	29.5	62.4	14	3.1900	0.398	11.744304

Jumper Length	Jumper wire size	Jumper resistance	Jumper resistance	Voltage Drop of Jumper	DCB Whip length	DCB Whip wire size	DCB Whip resistance	DCB Whip resistance	Voltage Drop of DCB Whip	Total resistance	Total voltage drop	Voltage drop for branch
feet	AWG	Ohm/kft	Ohm	Volts	feet	AWG	Ohm/kft	Ohm	Volts	Ohm	Volts	percent
193.75	12	2.0100	0.779	22.9768125	1.23705666	7	0.4982	0.001	0.036	1.177	34.757	3.58%
131.35	12	2.0100	0.528	15.5767965	1.23705666	7	0.4982	0.001	0.036	0.926	27.357	2.81%
68.95	12	2.0100	0.277	8.1767805	1.23705666	7	0.4982	0.001	0.036	0.675	19.957	2.05%
6.55	12	2.0100	0.026	0.7767645	1.23705666	7	0.4982	0.001	0.036	0.424	12.557	1.29%
6.55	12	2.0100	0.026	0.7767645	1.23705666	7	0.4982	0.001	0.036	0.424	12.557	1.29%
68.95	12	2.0100	0.277	8.1767805	1.23705666	7	0.4982	0.001	0.036	0.675	19.957	2.05%
131.35	12	2.0100	0.528	15.5767965	1.23705666	7	0.4982	0.001	0.036	0.926	27.357	2.81%
193.75	12	2.0100	0.779	22.9768125	1.23705666	7	0.4982	0.001	0.036	1.177	34.757	3.58%

DCB11-01	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB11-02	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB11-00	1.57111						
DCB11-03	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB11-04	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB11-05	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB11-06	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB11-07	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB12-01	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB12-02	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB12-00	.5.211.1						
DCB12-03	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB12-04	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB12-05	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB12-06	2	29.5	62.4	14	3.1900	0.398	11.744304
DCB12-07	2	29.5	62.4	14	3.1900	0.398	11.744304

198.842	12	2.0100	0.799	23.58067278	1.23705666	7	0.4982	0.001	0.036	1.197	35.361	3.64%
136.442	12	2.0100	0.548	16.18065678	1.23705666	7	0.4982	0.001	0.036	0.946	27.961	2.88%
6.55	12	2.0100	0.026	0.7767645	1.23705666	7	0.4982	0.001	0.036	0.424	12.557	1.29%
6.55	12	2.0100	0.026	0.7767645	1.23705666	7	0.4982	0.001	0.036	0.424	12.557	1.29%
68.95	12	2.0100	0.277	8.1767805	1.23705666	7	0.4982	0.001	0.036	0.675	19.957	2.05%
131.35	12	2.0100	0.528	15.5767965	1.23705666	7	0.4982	0.001	0.036	0.926	27.357	2.81%
193.75	12	2.0100	0.779	22.9768125	1.23705666	7	0.4982	0.001	0.036	1.177	34.757	3.58%
203.934	12	2.0100	0.82	24.18453306	1.23705666	7	0.4982	0.001	0.036	1.218	35.965	3.70%
141.534	12	2.0100	0.569	16.78451706	1.23705666	7	0.4982	0.001	0.036	0.967	28.565	2.94%
6.55	12	2.0100	0.026	0.7767645	1.23705666	7	0.4982	0.001	0.036	0.424	12.557	1.29%
6.55	12	2.0100	0.026	0.7767645	1.23705666	7	0.4982	0.001	0.036	0.424	12.557	1.29%
131.35	12	2.0100	0.528	15.5767965	1.23705666	7	0.4982	0.001	0.036	0.926	27.357	2.81%
193.75	12	2.0100	0.779	22.9768125	1.23705666	7	0.4982	0.001	0.036	1.177	34.757	3.58%
131.35	12	2.0100	0.528	15.5767965	1.23705666	7	0.4982	0.001	0.036	0.926	27.357	2.81%

DCB	No. of Rack Inputs	IMP for circuit	Feeder length	Feeder wire size	Feeder resistance	Feeder resistance	Voltage drop for feeder	Voltage drop for feeder	Voltage drop for circuit	VMP for circuit	Voltage drop
DCB#-##	#	Amp	feet	AWG	Ohm/kft	Ohm	Volt	per cent	Volt	Volt	per cent
DCB1	8	29.5	341.1333333	6	0.5100	0.3480	10.264702	0.13%	199.524	7776	2.57%
DCB2	8	29.5	316.1150133	6	0.5100	0.3224	9.5 <mark>1</mark> 1900751	0.12%	198.772	7776	2.56%
DCB3	8	29.5	291.0966933	6	0.5100	0.2969	8.759099502	0.11%	198.019	7776	2.55%
DCB4	8	29.5	266.0783733	6	0.5100	0.2714	8.006298254	0.10%	197.266	7776	2.54%
DCB5	8	29.5	241.0600533	6	0.5100	0.2459	7.253497005	0.09%	196.513	7776	2.53%
DCB6	8	29.5	216.0417333	6	0.5100	0.2204	6.500695756	0.08%	195.760	7776	2.52%
DCB7	8	29.5	191.0234133	6	0.5100	0.1948	5.747894507	0.07%	195.008	7776	2.51%
DCB8	8	29.5	166.0050933	6	0.5100	0.1693	4.995093258	0.06%	194.255	7776	2.50%
DCB9	8	29.5	140.9867733	6	0.5100	0.1438	4.24229201	0.05%	193.502	7776	2.49%
DCB10	8	29.5	115.9684533	6	0.5100	0.1183	3.489490761	0.04%	192.749	7776	2.48%
DCB11	7	29.5	90.95013333	6	0.5100	0.0928	2.736689512	0.04%	173.247	6804	2.55%
DCB12	7	29.5	115.9684533	6	0.5100	0.1183	3.489490761	0.05%	182.607	6804	2.68%
DCB13	8	29.5	124.0873333	6	0.5100	0.1266	3.73378786	0.05%	192.993	7776	2.48%
DCB14	8	29.5	149.1056533	6	0.5100	0.1521	4.486589109	0.06%	193.746	7776	2.49%
DCB15	8	29.5	174.1239733	6	0.5100	0.1776	5.239390358	0.07%	175.749	7776	2.26%
DCB16	8	29.5	199.1422933	6	0.5100	0.2031	5.992191606	0.08%	195.252	7776	2.51%
DCB17	8	29.5	224.1606133	6	0.5100	0.2286	 6.744992855	0.09%	196.005	7776	2.52%
DCB18	8	29.5	249.1789333	6	0.5100	0.2542	7.497794104	0.10%	196.757	7776	2.53%
DCB19	8	29.5	274.1972533	6	0.5100	0.2797	8.250595353	0.11%	197.510	7776	2.54%
DCB20	8	29.5	299.2155733	6	0.5100	0.3052	9.003396602	0.12%	198.263	7776	2.55%
DCB21	8	29.5	324.2338933	6	0.5100	0.3307	9.75619785	0.13%	199.016	7776	2.56%
DCB22	8	29.5	349.2522133	6	0.5100	0.3562	10.5089991	0.14%	199.769	7776	2.57%
							74.7		pc=	voltage drop:	2.52%

3		5) 8	9	Env	INVE	RTER DC FU	SE IDENTIFICA	ATION	35
	Disconnect Combiner Box NUMBER	INPUT DC FUSE SIZE	NUMBER OF STRINGS	NUMBER OF INPUTS	SHORT CIRCUIT CURRENT (ISC)	MAX POWER CURRENT (IMP)	OWER POWER DC FEED WIPE SIZE AN	DC FEEDER WIRE SIZE AND TYPE	ONE WAY DISTANCE NOT TO EXCEED
3	DCB#-##	AMP		X	AMP	AMP	VOLT		(FT)
- P				0	18.8	29.50	972		
8	DCB1-01	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
	DCB1-02	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
3	DCB1-03	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
3	DCB1-04	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
	DCB1-05	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
- 8	DCB1-06	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
8	DCB1-07	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
.0	DCB1-08	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
9	DCB1-09	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
2	DCB1-10	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	1
4	DCB1-11	210	14	7	131	207	6804	(<1>) - <6 AWG Copper Underground>	
1	DCB1-12	210	14	7	131	207	6804	(<1>) - <6 AWG Copper Underground>	
NVENIEN	DCB1-13	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
100	DCB1-14	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
Š	DCB1-15	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
Ü	DCB1-16	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
3	DCB1-17	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
	DCB1-18	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	1
3	DCB1-19	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
3	DCB1-20	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
- 0	DCB1-21	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	1
8	DCB1-22	240	16	8	150	236	7776	(<1>) - <6 AWG Copper Underground>	
	INVERTER	1 TOTALS	348	174	3265	5133	7776		

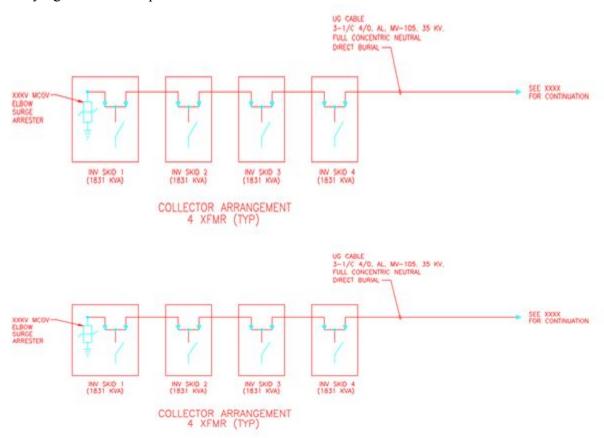
Circuit	from	to	power (W)	Voltage (Vmp)	Current (Imp)	DCB Fuse (A)	Cable Size (AWG)	Cable Length (Ft)
1	ER - 1	DCB	28,674	972	29.5	30	12	193.75
2	ER - 2	DCB	28,674	972	29.5	30	12	131.35
3	ER - 3	DCB	28,674	972	29.5	30	12	68.95
4	ER - 4	DCB	28,674	972	29.5	30	12	6.55
5	ER - 5	DCB	28,674	972	29.5	30	12	6.55
6	ER - 6	DCB	28,674	972	29.5	30	12	68.95
7	ER - 7	DCB	28,674	972	29.5	30	12	131.35
8	ER - 8	DCB	28,674	972	29.5	30	12	193.75
Tot	tal:		229,392		236			

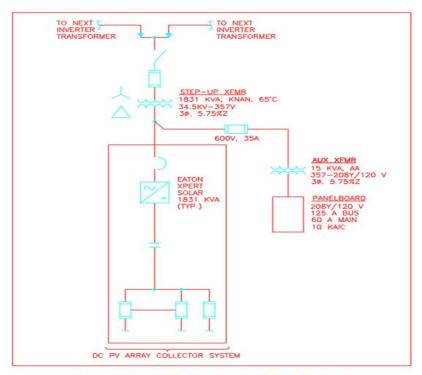
Circuit	from	to	power (W)	Voltage (Vmp)	Current (Imp)	DCB Fuse (A)	Cable Size (AWG)	Cable Length (Ft)
1	ER - 1	DCB	28,674	972	29.5	30	12	198.842
2	ER - 2	DCB	28,674	972	29.5	30	12	136.442
3	ER - 3	DCB	28,674	972	29.5	30	12	6.55
4	ER - 4	DCB	28,674	972	29.5	30	12	6.55
5	ER-5	DCB	28,674	972	29.5	30	12	68.95
6	ER-6	DCB	28,674	972	29.5	30	12	131.35
7	ER - 7	DCB	28,674	972	29.5	30	12	193.75
Tot	tal:		200,718	200 201 1	206.5			

	20				0.00	0.00	6.11	4.00
Circuit	from	to	power (W)	Voltage (Vmp)	Current (Imp)	DCB Fuse (A)	Cable Size (AWG)	Cable Length (Ft)
1	ER - 1	DCB	28,674	972	29.5	30	12	203.934
2	ER - 2	DCB	28,674	972	29.5	30	12	141.534
3	ER - 3	DCB	28,674	972	29.5	30	12	6.55
4	ER - 4	DCB	28,674	972	29.5	30	12	6.55
5	ER - 5	DCB	28,674	972	29.5	30	12	131.35
6	ER - 6	DCB	28,674	972	29.5	30	12	131.35
7	ER - 7	DCB	28,674	972	29.5	30	12	193.75
Tot	tal:		200,718		206.5			

Ahmed and Chufu:

- Transformer rating calculation
- output collector current calculation
- AutoCAD drawing
- Modifying the collector parameters bases on the calculations





1831 KVA INVERTER TRANSFORMER DETAIL

The max current output of 1 skid (inverter and transformer)

Using the AUX XFNR 15 KVA

I = 15000 VA / (208*1.732) = 41 A

Each collector is attached to 3 inverter skid the total Amp is 123 A

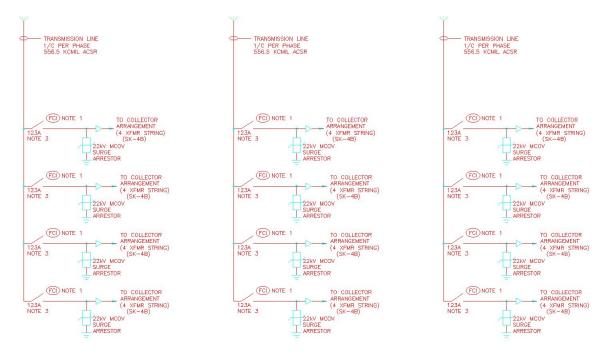
3 Phase Transformer

Max current = 3000 A

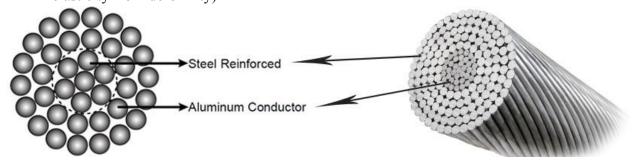
Rated Voltage = 357

Transformer rating = (3000*357*1.732) = 1854 KVA

Tam and YJ: -



Conductor for Feeder Line
 Aluminum Conductor Steel Reinforced (ACSR)
 High-purity aluminum for good conductivity, low weight, and cost
 Zinc coated steel core wire is for strength to support the weight of the conductor (lower elasticity from deformity)



- About ACSR

Given from the AutoCAD, the size that we are choosing for ACSR is 556.5KCM. Which one of these should we choose?

Current per feeder = $4 \times 123 \text{ A}$

$$= 492 A$$

				Resistance (OHM S/1000 ft.	
Code Word	Size (AWG or kcmil)	Strand- ing (Al/Stl)	Rated Strength (lbs.)	DC @ 20°C	AC @ 75°C	Allowable Ampacity+ (Amps)
Osprey	556.5	18/1	13700	.0308	.0379	711
Parakeet	556.5	24/7	19800	.0307	.0376	721
Dove	556.5	26/7	22600	.0308	.0375	726
Eagle	556.5	30/7	27800	.0303	.0372	734
Ostrich	300	26/7	12700	.0567	.0693	492
Merlin	336.4	18/1	8680	.0510	.0825	519
Linnet	336.4	26/7	14100	.0505	.0618	529
Oriole	336.4	30/7	17300	.0502	.0813	535

Pending Issues:

- In the voltage drop calc template, what is "one way distance not to exceed" referring to?

Plans For Next Week:

Kat and Nur:

- Rearrange solar plant components in array rows 11 and 12
- Produce final versions of solar layout and voltage drop calculations based on client's feedback

Tam and YJ: -

- Finalize everything about feeder.

Amed and Chufu: -

- Finalize everything about collector.

Individual Contributions

Team Member	Individual Contributions	Hours	Cumulative Hours
Katayi Katanga	Did research on: - Voltage drop - NEC Created/Performed: - Voltage drop calculations - Conductor Sizing - Plan for wiring - Attend all meetings	10	87
Nur Shuazlan	Did research on: - Voltage drop - NEC Created/Performed: - Voltage drop calculations - Conductor Sizing - Plan for wiring - Attend all meetings	10	89

Yao Cheah (YJ)	Did research on: - Conductor for feeder - Surge arrestor properties Created/Performed: - Attended all meetings - Did safety moment	8.5	62
Ahmed Sobi	Did research on: - 3 phase transformer rating - Inverter specification - Inverter skid layout - Output current of the transformer Created/Performed: - Skid parameters - AutoCAD pdf version - calculation for collector parameters - Attended all meetings	17.5	80
Tam Nguyen	Did research on: - Conductor for feeder - Price of surge arrester Created/Performed: - Weekly report - Meeting agenda - Attend one meeting	6	64.5
Chufu Zhou	Did research on: - 3 phase transformer rating - Inverter specification - Inverter skid layout - Output current of the transformer Created/Performed: - Wiring diagram of array layout	12	59

Team Hours: 64

Cumulative Team Hours: 441.5