Week 4 Meeting

9/24/18
Team Leader: Katayi
Other Team Members: Nur, Chufu, Tam, Ahmed, YJ
Advisor: Dr. Ajjarapu

Topics

- Solar Power Plant Cost
- Solar Power Plant Sketch (rough draft)
- Solar Plant / Substation Location Review (ames solar & miso solar)
- Single line substation diagram (rough draft)
- Justification
  - Panel: Hanwha 325W
- Gantt Chart (rough draft)

Safety Moment

We use batteries in many things today like clocks, toys, decoration stuff, and even in your car because it's cheap, small, and providing small amount of power. However, the chemicals in the batteries are harmful and they can make explosion. Therefore, Do Not mix batteries in different brands, different types, new and old batteries; Do Not use leaking or damaged batteries; and be aware about the polar when installing.

Solar Power Plant Cost

- We will be using a total of 237,312 panels that cost $204 per panel $48,411,648.
- A total of 252 combiner boxes will be used with a price of appx $1280.56 per CB coming up to a total of $322,701.
- We will use a total of 46 inverters, with an appx cost of $432,118.75 per 1666 kW inverter (estimated using price of 208 8kW inverters), making a total of $19,877,462.50.
- Land has been listed at a price of $12,000 per acre (California), tentative area to be used is appx 243.8 acres making it $2,925,600.
- Total tentative cost of the project is:
    - $2,925,600+$19,877,462.50+$322,701+$48,411,648 = $71,537,411.50
- The panels are the most expensive component of the solar plant

Solar Power Plant Cost

Solar Plant Cost		
Panels	48.411648	million $
CBs	0.32270112	million $
Inverters	19.8774625	million $
Land	2.925552901	million $
Total Cost	71.53736452	million $

Strings, Racks, Combiner Boxes

String Size				Electrical Rack Size				CB capacity		
					2 in portrait					
Min Temp	13.5	C		Module width	6.541667	ft		mod/string Isc	9.44	A
				module height	3.283333	ft		multiplier	1.25	
Voc	46.43	V						nom Isc	11.8	
Ref temp	25	C		rack width	32	panels		multiplier	1.25	
				rack height	2	panels		max Isc	14.75	A
Temp Coeff of Voc	0.001066	/C		Panels per rack	64					
Temp delta	-11.5			rack width	209.3333	ft		allowed current	500	A
temp correction	0.99			rack height	6.566667	ft				
V0c corrected	45.86103							strings per CB	33.89831	
				Strings per rack	2				33	
string voltage	1500	V						racks per CB	16.5	
String size	32.7075			Power per rack	20.8	kW		current going into CB	486.75	A
string size	32	panels								
Actual String Voltage	1467.6	V						Power per CB	343.2	kW

Array Design and Size

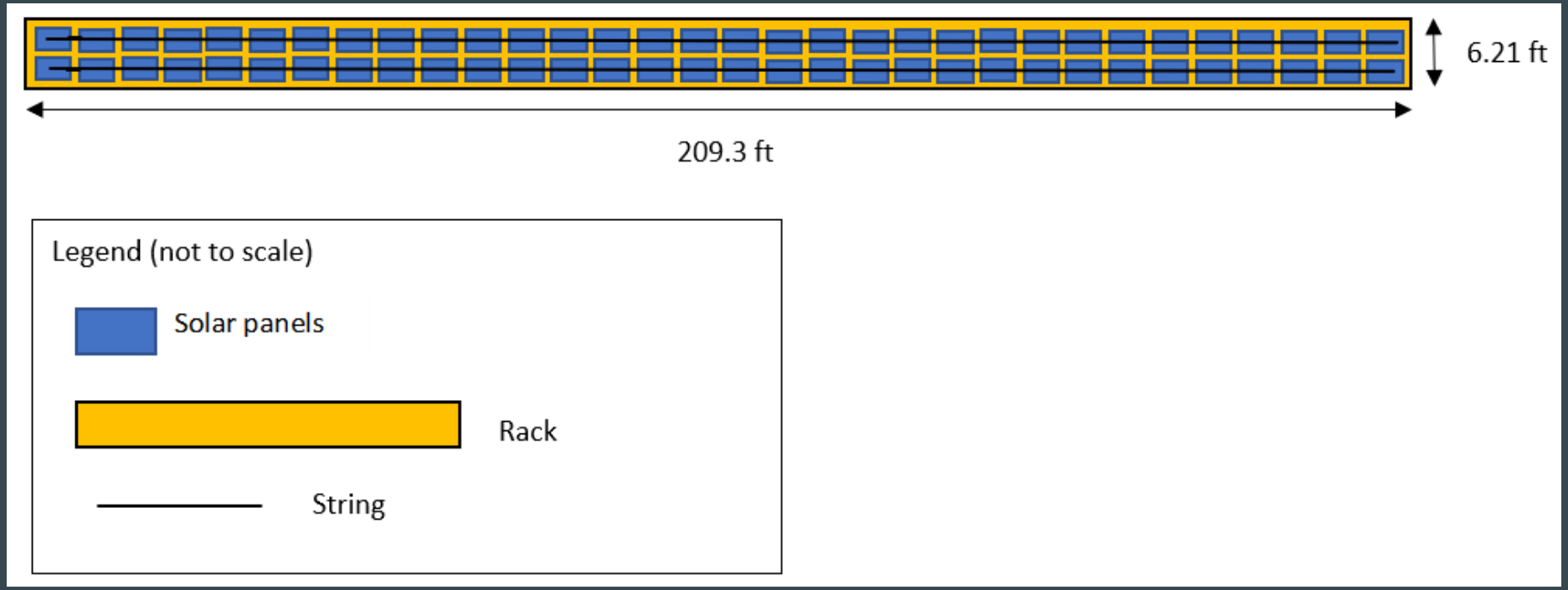
Array Design				Array Size			
racks per row of array	5			tilt		19.05	degrees
rows per array	21			rack height proj		6.207037	ft
racks removed	2			row spac		6.41021	ft
Total racks per array	103			pitch		12.61725	ft
Inverters in an array	1.285954						
Total panels in Array	6592			array height		264.9622	ft
Strings per array	206						
panel capacity	325	W		array width		1046.667	ft
CBs per array	6.242424		7				
dc capacity per array	2.1424	MW					
inverter capacity	1.666	MW					
inverter s capacity	1.831	MVA					
ILR	1.285954						

Solar Plant Size, Total Components, and Cost

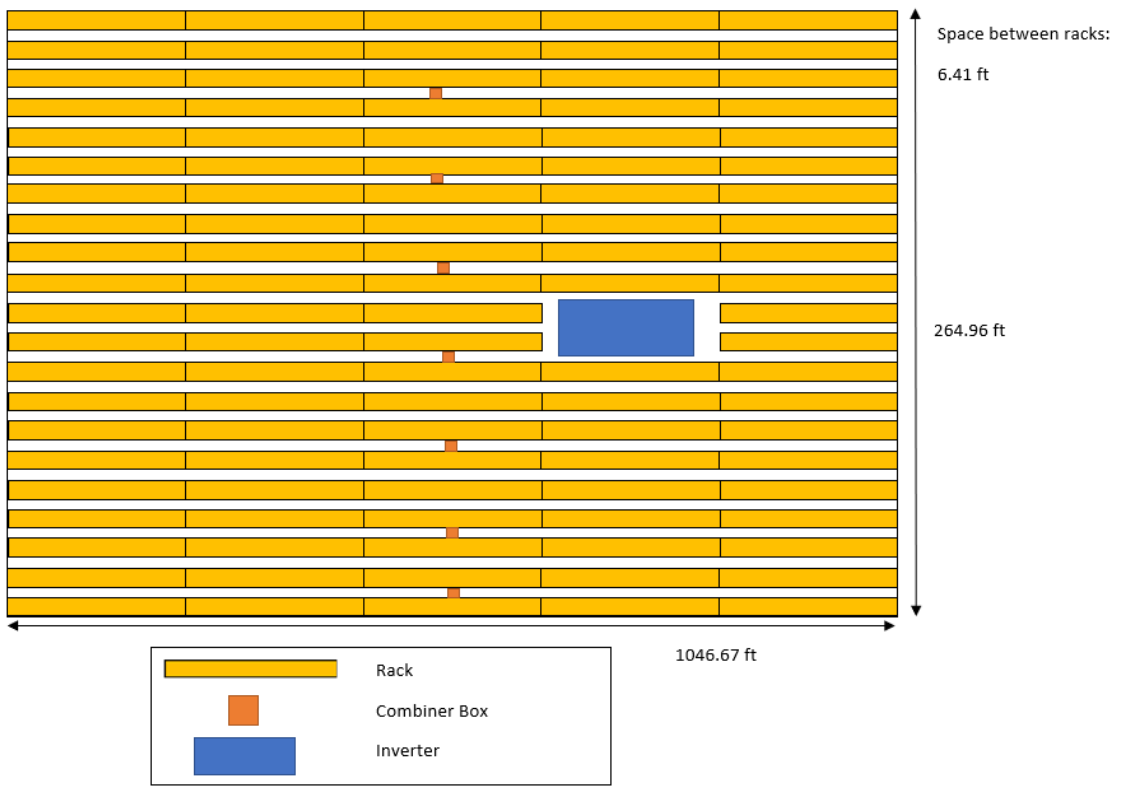
	Solar Plant		
	Arrays in Plant	36.01441	36
If we use 36 arrays:	Panels in Plant	237312	
	Inverters in Plant	46.29436	46
	CBs in Plant	252	
	DC Plant Output	77.1264	MW
	AC Plant Output	60	MW
	ILR	1.28544	

Solar Plant Size				Total Components		
Access Road	16	ft		Panels	237312	
Height	1669.773118	ft		CBs	252	
Width	6360	ft		1666 kW Inverters	46	
				8 kW Inverters to make a 1666 kW inverter	208.25	inverters
Area of Plant	10619757.03	ft^2		8 kW inverters for plant	9579.5	inverters
	243.7960751	acres				

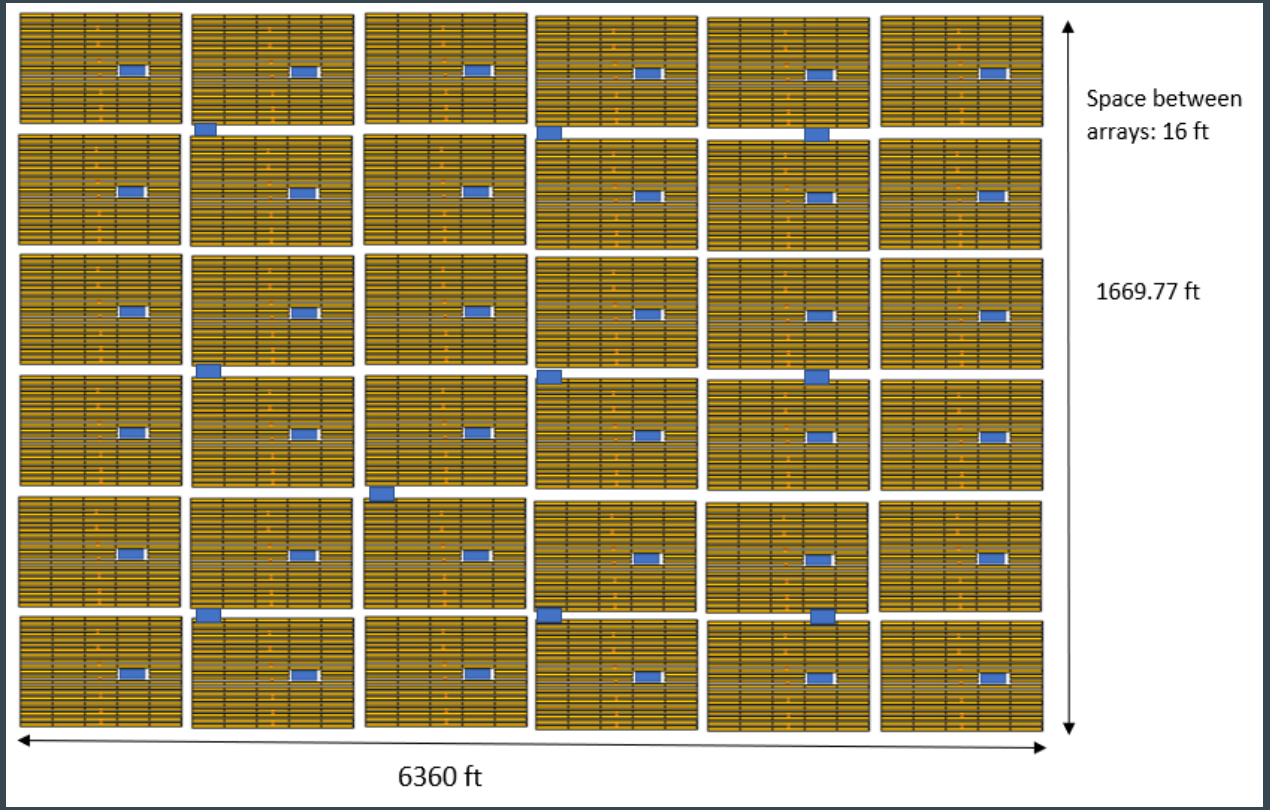
Single Rack Layout (2x32 Panels, 2 Strings)



Single Array Layout (21x5 - 2 Racks, 7 CB, 1.286 Inverters)



Solar Power Plant Layout (36 Arrays, 46 Inverters)



Solar Plant / Substation Location Review (ames solar & miso solar)

MISO North Star Solar Project details

- 100 MW of solar pv capacity (440,000 modules)
- About 800 acres of agricultural land
- Single axis tracking to maximize production
- Grid connection at the Chicago substation 115kV

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	2.30	6,368,643
February	3.58	8,684,875
March	5.00	13,438,976
April	6.45	15,626,717
May	7.15	17,410,074
June	8.11	18,581,528
July	8.58	19,558,118
August	7.23	16,874,242
September	5.53	13,044,710
October	3.71	9,475,508
November	2.41	6,201,953
December	1.88	5,095,326
Annual	5.16	150,360,670

Solar Plant / Substation Location Review (ames solar & miso solar)

Why not Iowa? Even though solar is booming in the Midwest

- Cheaper land but whether conditioning is bad (long winter, cloudy, and rainy)
- The system would require axis tracking to accommodate for solar radiation
- Require bigger budget to purchase top notch resources.
- Lower grid capacity

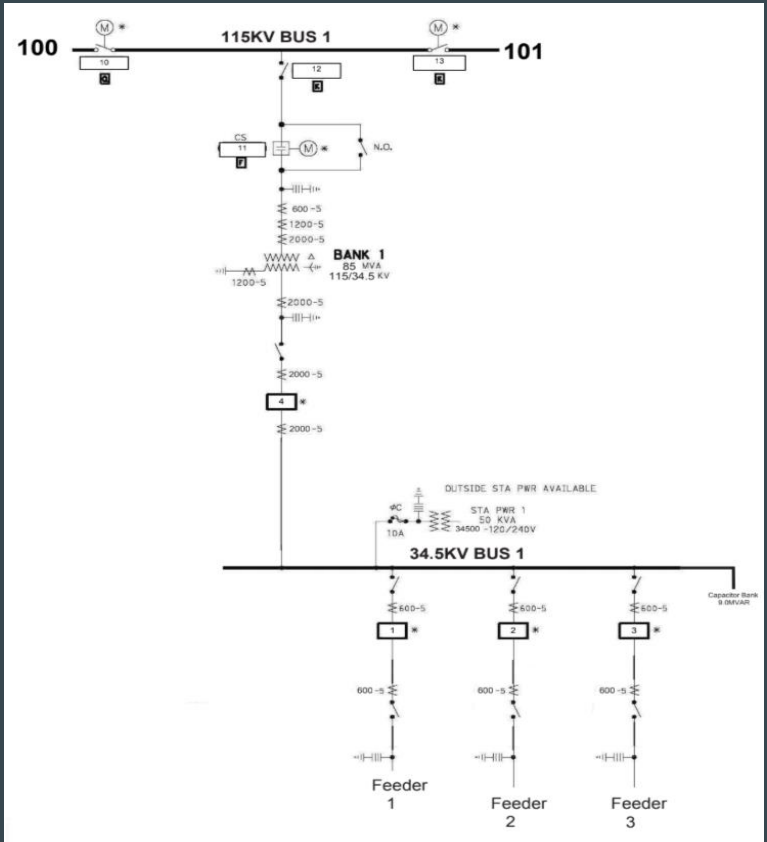
Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	2.66	4,402,616
February	3.75	5,397,222
March	4.66	7,393,330
April	5.53	7,948,084
May	5.89	8,535,323
June	6.49	8,867,109
July	6.83	9,270,547
August	5.97	8,275,837
September	4.99	6,949,373
October	3.66	5,534,203
November	2.70	4,147,131
December	2.21	3,612,150
Annual	4.61	80,332,925

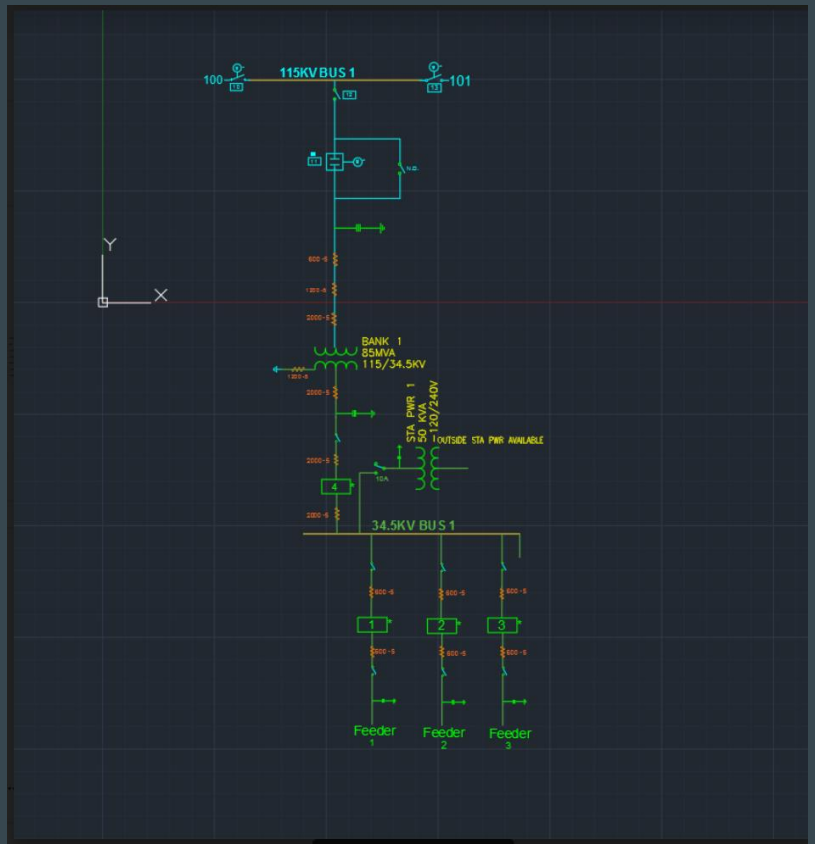
Solar Plant / Substation Location Review (ames solar & miso solar)

Places to consider Arizona, Texas, New Mexico

- Almost perfect weather condition for Solar
- Abundant of desert land (cheaper and high solar radiation)
- No axis tracking require (cost reduction)
- Bigger grid capacity

Single Line Diagram Rough Draft





Eaton : Power Xpert Solar 1670

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Input Characteristics, Central Inverters, DC

PV Array Power Range (kWp)	1670
Voltage Range MPPT	550 to 1000
Max Voltage DC	1000
Max Current (A)	3100
Number Of DC Inputs	Up to 24

Output Characteristics (AC)

Rated Power (kW)	1666kW / 1830kVA
Max Current (A@V)	3000
Rated Voltages (V)	357V
Frequency (Hz)	60

EFFICIENCY

Peak %	98.70%
CEC wtd %	98.5

GENERAL INFORMATION

Consumption (W) Day	
Consumption (W) Night	334.42
Operating °C range	-20 to 50
Warranty (Years)	5 to 10
Weight (lb)	12500

Solar Panel Material (Monocrystalline vs Polycrystalline)

Monocrystalline

- Higher silicon purity, more efficiency (18.5%, 16.77%, highest 19.77%)
- Range $300 - $700

Polycrystalline

- Utilize all silicon material, less purity and efficiency (16.3%)
- Range $200 - $500

Reason of choosing Hanwha 325W

- More cost effective, has 16.3% efficiency
- One of the cheapest on market

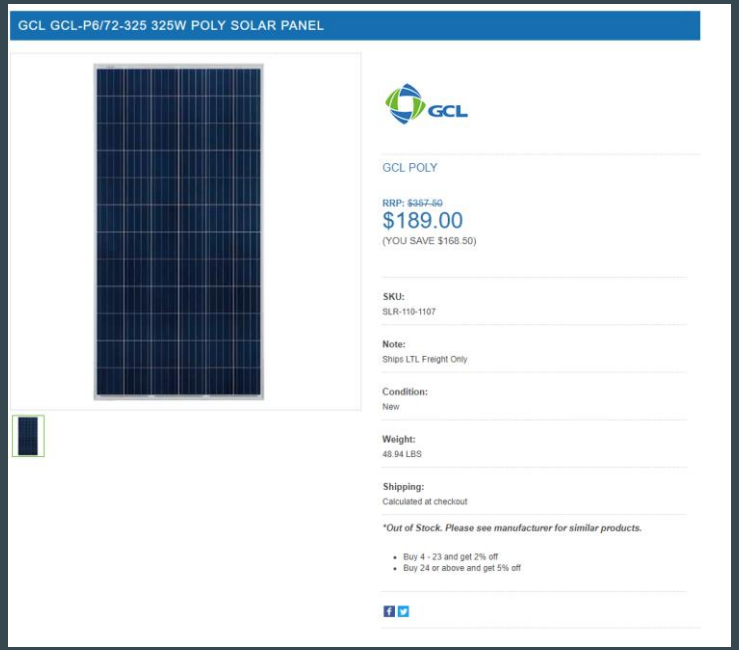
ELECTRICAL CHARACTERISTICS								
POWER CLASS				320	325	330	335	340
MINIMUM PERFORMANCE AT STANDARD TEST CONDITIONS, STC[1] (POWER TOLERANCE +5 W / -0 W)								
Minimum	Power at MPP[2]	P_{MPP}	[W]	320	325	330	335	340
	Short Circuit Current*	I_{SC}	[A]	9.39	9.44	9.49	9.54	9.59
	Open Circuit Voltage*	V_{OC}	[V]	46.17	46.43	46.68	46.94	47.20
	Current at MPP*	I_{MPP}	[A]	8.79	8.85	8.91	8.97	9.03
	Voltage at MPP*	V_{MPP}	[V]	36.39	36.70	37.02	37.33	37.63
	Efficiency[2]	η	[%]	≥16.0	≥16.3	≥16.5	≥16.8	≥17.1
MINIMUM PERFORMANCE AT NORMAL OPERATING CONDITIONS, NOC[3]								
Minimum	Power at MPP[2]	P_{MPP}	[W]	237.2	241.0	244.7	248.4	252.1
	Short Circuit Current*	I_{SC}	[A]	7.57	7.61	7.65	7.69	7.73
	Open Circuit Voltage*	V_{OC}	[V]	43.08	43.32	43.56	43.81	44.05
	Current at MPP*	I_{MPP}	[A]	6.89	6.94	6.99	7.04	7.09
	Voltage at MPP*	V_{MPP}	[V]	34.44	34.72	35.01	35.29	35.56

[1] 1000 W/m², 25°C, spectrum AM 1.5G [2] Measurement tolerances STC ±3%; NOC ±5% [3] 800 W/m², NOCT, spectrum AM 1.5G * typical values, actual values may differ

Other option on solar panel

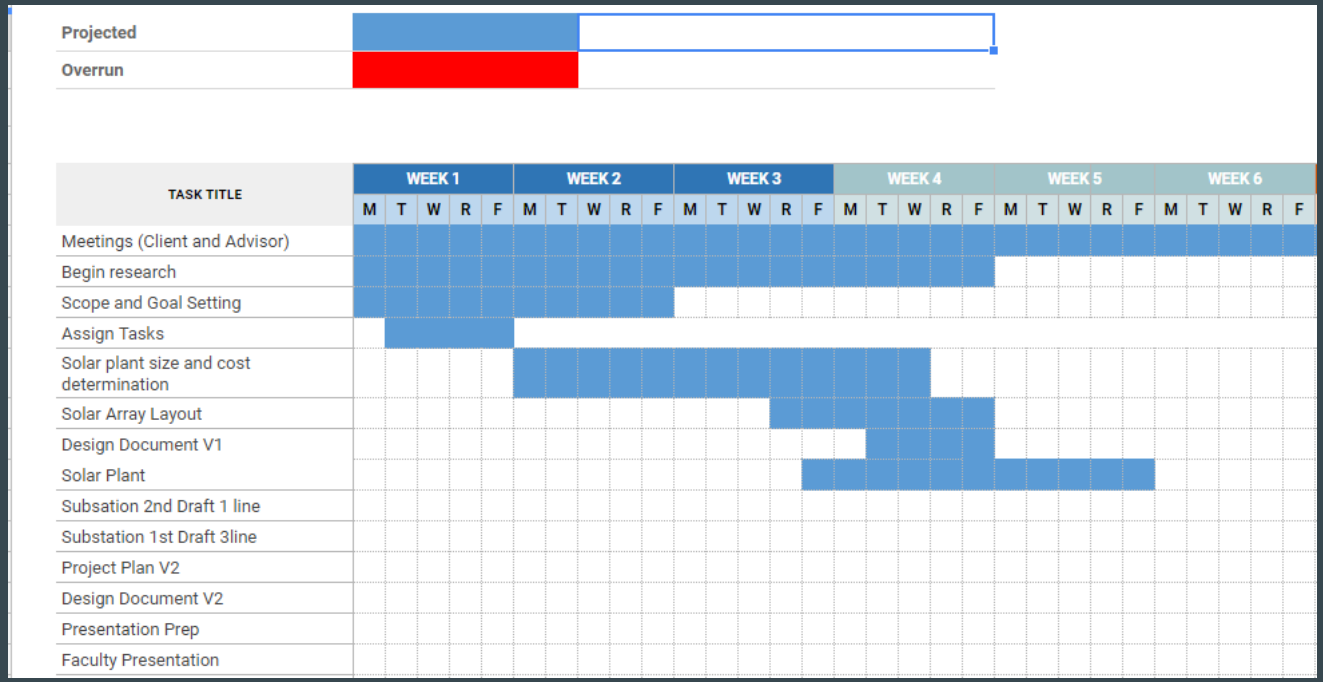
Cheaper solar panel with slightly higher efficiency

- Price: $189 per panel
- Efficiency: 16.7% (Hanwha has 16.3%)



Gantt Chart (Rough Draft)

- Changes will be made as we go



Questions That We Have

- It's hard to find the prices of inverter, panel, and the rack because most of the prices we found is for household stuff. So will the price of the stuff we use for our plant be from dealing between B&V and supplier? Or can we use the price for household to estimate the price?
- Can we use a combiner box of our choosing?
- Should we round down or up when using the array parameter tool for number of inverters? When we round down we use less inverters than when we don't
- Some certain elements in AutoCAD (Library for Electrical doesn't show clearly)