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Department of Electrical and Computer Engineering

115/34.5kV Solar Plant & Substation Senior Design Project

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| Senior Design Team 41

| 10/31/2024

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Agenda

- Safety Moment
- New Technology
- Voltage Drop Calculation
- Expand on Cost Estimations
- Drawings for Project: 1 line/2D drawings for solar array
- Plant for Array

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Safety Moment

Remote Site and Communication Safety

- *Definition*: refers to the measures and protocols implemented to ensure secure, reliable, and efficient communication between the solar farm and off-site control centers, monitoring systems, and personnel.
- *Why?* Ensure workers safety, prevents unauthorized access, enable real-time monitoring and alerts, facilitate effective coordination, enhance situational awareness, emergency rescue and evacuation, support safe maintenance and repairs.
- *Site Security measures*:

1. Communications: Two-way radio and/or cell phone in audible ring mode.
2. Site Access Control: Un-manned.
3. Electronic Security and surveillance.
4. Security Lightning.
5. List of Local Public Safety Agencies.

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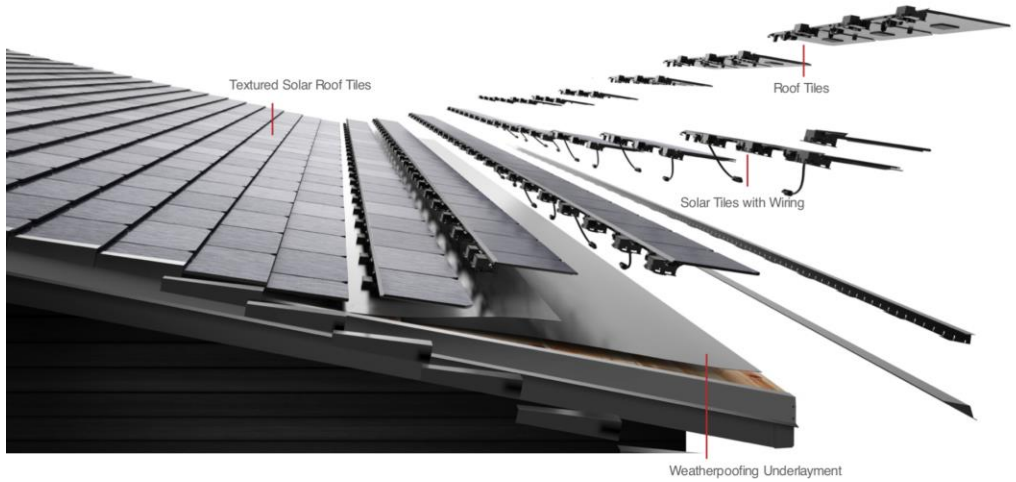
New Technology

Building-Integrated Photovoltaics (BIPV)

- BIPV technology integrates solar panels into building materials, such as roofs, windows, and facades, making the panels part of the structure itself.

Benefits: Aesthetic appeal, dual-purpose for construction and energy generation, reduces the need for separate mounting structures.

For any structures within a substation or solar plant, BIPV could be a great option for aesthetics and functionality



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Voltage Drop Calculation

Jumper voltage drop

DCB	Strings per Rack	IMP for String	String Length	String wire size	String Conductor resistance	String resistance	Voltage Drop of String	IMP for Jumper	Jumper Length	Jumper wire size	Jumper resistance	Jumper resistance	Voltage Drop of Jumper	%Voltage Drop of string
DCB#-##	per rack	Amp	feet	AWG	Ohm/kft	Ohm	Volts	Amp	feet	AWG	Ohm/kft	Ohm	Volts	per cent
DCB1-01	2	14	226.87	10	1.2400	0.5448151	7.876926	28	567	8	0.7640	0.8380282	24.258528	0.525128427
DCB1-02	2	14	226.87	10	1.2400	0.5448151	7.876926	28	340	8	0.7640	0.503204	14.54656	0.525128427
DCB1-03	2	14	226.87	10	1.2400	0.5448151	7.876926	28	113	8	0.7640	0.1674121	4.834592	0.525128427
DCB1-04	2	14	226.87	10	1.2400	0.5448151	7.876926	28	340	8	0.7640	0.503204	14.54656	0.525128427
DCB1-05	2	14	226.87	10	1.2400	0.5448151	7.876926	28	567	8	0.7640	0.8380282	24.258528	0.525128427
Combiner Name		from Array Parameter	panels in string * panel width	IMP x 1.25 AWG size above that	Table 8 NEC						Table 8 NEC			

Array voltage drop

DCB	No. of Rack Inputs	IMP for DCB 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 for circuit
DCB#-##	#	Amp	feet	kcmil	Ohm/kft	Ohm			Volt	per cent	Volt	Volt		per cent
DCB1	5	140.00	767.7	600	0.0214	0.0318			4.6000584	0.47%	42.1431528	1500.00		2.81%
DCB2	5	140.00	751.7	600	0.0214	0.0312			4.5041864	0.46%	42.11119547	1500.00		2.81%
DCB3	5	140.00	735.7	600	0.0214	0.0305			4.4083144	0.45%	42.07923813	1500.00		2.81%
DCB4	5	140.00	719.7	600	0.0214	0.0298			4.3124424	0.44%	42.0472808	1500.00		2.80%
DCB5	5	140.00	703.7	600	0.0214	0.0291			4.2165704	0.43%	42.01532347	1500.00		2.80%
DCB6	5	140.00	687.7	600	0.0214	0.0285			4.1206984	0.42%	41.98336613	1500.00		2.80%
DCB7	5	140.00	671.7	600	0.0214	0.0278			4.0248264	0.41%	41.9514088	1500.00		2.80%
DCB8	5	140.00	655.7	600	0.0214	0.0272			3.9289544	0.40%	41.91945147	1500.00		2.79%
DCB9	5	140.00	639.7	600	0.0214	0.0265			3.8330824	0.39%	41.88749413	1500.00		2.79%
DCB10	5	140.00	623.7	600	0.0214	0.0258			3.7372104	0.38%	41.8555368	1500.00		2.79%
DCB11	5	140.00	607.7	600	0.0214	0.0252			3.6413384	0.37%	41.82357947	1500.00		2.79%
DCB12	5	140.00	623.7	600	0.0214	0.0258			3.7372104	0.38%	41.8555368	1500.00		2.79%
DCB13	5	140.00	767.7	600	0.0214	0.0318			4.6000584	0.47%	42.1431528	1500.00		2.81%
DCB14	5	140.00	751.7	600	0.0214	0.0312			4.5041864	0.46%	42.11119547	1500.00		2.81%
DCB15	5	140.00	735.7	600	0.0214	0.0305			4.4083144	0.45%	42.07923813	1500.00		2.81%
DCB16	5	140.00	719.7	600	0.0214	0.0298			4.3124424	0.44%	42.0472808	1500.00		2.80%
DCB17	5	140.00	703.7	600	0.0214	0.0291			4.2165704	0.43%	42.01532347	1500.00		2.80%
DCB18	5	140.00	687.7	600	0.0214	0.0285			4.1206984	0.42%	41.98336613	1500.00		2.80%
DCB19	5	140.00	671.7	600	0.0214	0.0278			4.0248264	0.41%	41.9514088	1500.00		2.80%
DCB20	5	140.00	655.7	600	0.0214	0.0272			3.9289544	0.05%	41.91945147	1500.00		2.79%
DCB21	5	140.00	639.7	600	0.0214	0.0265			3.8330824	0.05%	41.88749413	1500.00		2.79%
DCB22	5	140.00	623.7	600	0.0214	0.0258			3.7372104	0.05%	41.8555368	1500.00		2.79%
DCB23	5	140.00	607.7	600	0.0214	0.0252			3.6413384	0.05%	41.8555368	1500.00		2.79%
DCB24	5	140.00	565.7	600	0.0214	0.0234			3.3896744	0.04%	41.8555368	1500.00		2.79%
DCB25	5	140.00	591.7	600	0.0214	0.0253			3.5454664	0.05%	41.8555368	1500.00		2.79%
DCB26	5	140.00	575.7	600	0.0214	0.0246			3.4495944	0.04%	41.8555368	1500.00		2.79%
		sum total of combiner box current		IMP x 1.25AWG size ab(Table 8 NEC								Voltage your strings		Average of worst-case DCB vc 2.80%

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Cost Analysis Updates

- Updated Sunshine Per Year (Hours)
- Changed % Average Capacity to 75% based on previous group's values
  - Resulted in our Average Capacity to 45MW - is this alright?

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Solar Field Rating	% Average Capacity	Average Capacity	Sunshine Per Year	Life Time	Life Time	Life Time	New Mexico Electricty Cost	Price of Generation Factor	Generation Revenue	Annual Revenue	Construction Cost	O&M Costs	Salvage Value
2			(How much power do we expect to achieve from our solar power plant on average)												
3	Units	MW		MW	Hours	Years	MWH	kWH	Dollars/MWH		Dollars/MWH		(From BOM)		(From BOM)
4	Without Tracking	60	75%	45	3756	30	5070600	5070600000	$ 110.80	84%	$ 93.40	$15,787,211.69	XX	XX	XX
5	With Tracking	XX	XX	#VALUE!	XX	XX	#VALUE!	#VALUE!	XX	XX	#VALUE!	#VALUE!	XX	#VALUE!	XX
6		78													
7			Based on Last Years Group %	*If we bump up rat	*This value might need changed				Souce Found From (10/21/2024)	Souce Found From (10/28/2024)					
8			May Change/Depends on						Link from Source:	Link from Source:					
9			Our Components		https://www.weatherworld.com/climate-averages/nm/luna+c				EIA New Mexico	EIA Solar Generation					
10										Spreadsheet:					
11										AEO2023_LCOE-LCOS-LACE_figures.xlsx					
12										Note: NM is region #20					
13										Electricity Market Module Regions					
14		Dollars:	XX												
15															
16		Cents	#VALUE!												
17		kWH:	5070600000												
18															
19		Cents/kWH	#VALUE!												

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Research on Price of Generation Factor

From EIA Website Data:

- New Mexico is located in Region 20
- Levelized Cost of Electricity (LCOE) Region 20 = $17.40 Dollars/MWH

- Lower than US average
- (Iowa CLOE = $27.72 Dollars/MWH)

Levelized cost of electricity with including tax credits by region for new resources entering service in2028, AEO2023 Reference case (2022 dollars per megawatthour)

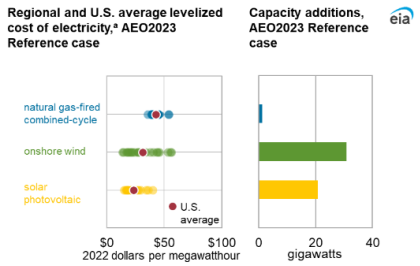
Technology	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	Region 11	Region 12	Region 13	Region 14	Region 15	Region 16	Region 17	Region 18	Region 19	Region 20
Advanced natural gas combined-cycle	$39.14	$44.75	$41.50	$41.60	$41.75	$39.38	$44.78	$48.01	$41.78	$39.14	$35.65	$44.35	$39.34	$42.26	$40.98	$41.01	$39.37	$42.36	$40.05	$43.52
Onshore wind	$37.65	NA	$18.13	$19.69	$27.41	$43.26	$33.63	NA	$40.24	$28.06	$22.43	$31.74	$56.31	$24.42	$55.14	$45.65	$17.32	$13.71	$14.67	$20.87
Solar photovoltaic	$16.12	$18.90	$27.72	$23.04	$26.87	$18.09	$35.92	$40.05	$34.24	$23.32	$22.19	$29.54	$21.45	$21.97	$17.13	$21.47	$15.10	$18.37	$22.64	$17.40

Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023*
Note: NA = not applicable

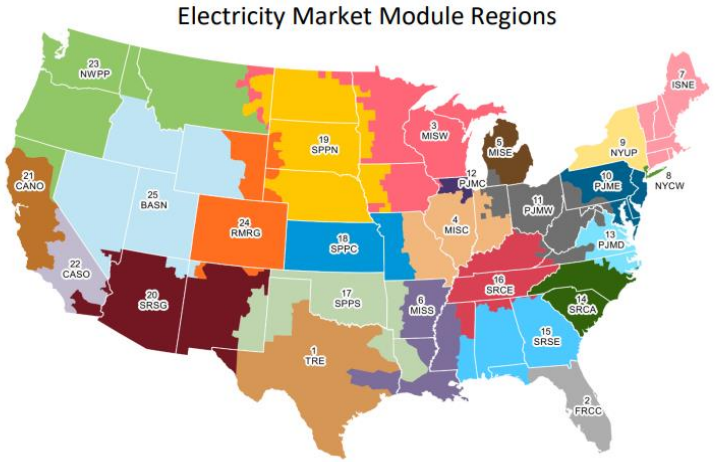
Capacity additions by region for new resources entering service in 2028, AEO2023 Reference case (gigawatts)

Technology	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	Region 11	Region 12	Region 13	Region 14	Region 15	Region 16	Region 17	Region 18	Region 19	Region 20
Advanced natural gas combined-cycle	1.069	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.152	0.000	0.000	0.000	0.000	0.000
Onshore wind	0.000	NA	15.652	0.000	0.000	0.000	1.175	NA	0.000	0.000	0.000	0.000	0.000	4.485	0.000	0.000	0.000	2.197	0.000	1.324
Solar photovoltaic	3.969	1.512	0.000	0.000	1.710	2.340	0.000	0.000	0.000	1.607	0.000	0.000	0.000	0.000	7.669	0.000	0.081	0.000	1.914	0.000

Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023*
Note: NA = not applicable



AEO2023_LCOE-LCOS-LACE_figures.xlsx



Region ID	NERC/ISO subregion	Geographic Name*
1- TRE	Texas Reliability Entity	Texas
2- FRCC	Florida Reliability Coordinating Council	Florida
3- MISW	Midcontinent ISO/West	Upper Mississippi Valley
4- MISC	Midcontinent ISO/Central	Middle Mississippi Valley
5- MISE	Midcontinent ISO/East	Michigan
6- MISS	Midcontinent ISO/South	Mississippi Delta
7- ISNE	NPCC/ New England	New England
8- NYCW	NPCC/NYC & Long Island	Metropolitan New York
9- NYUP	NPCC/Upstate NY	Upstate New York
10- PJME	PJM/East	Mid-Atlantic
11- PJMW	PJM/West	Ohio Valley
12- PJMC	PJM/Commonwealth Edison	Metropolitan Chicago
13- PJMD	PJM/Dominion	Virginia

Region ID	NERC/ISO subregion	Geographic Name*
14- SRCA	SERC Reliability Corporation/East	Carolinas
15- SRSE	SERC Reliability Corporation/Southeast	Southeast
16- SRCE	SERC Reliability Corporation/Central	Tennessee Valley
17- SPPS	Southwest Power Pool/South	Southern Great Plains
18- SPPC	Southwest Power Pool/Central	Central Great Plains
19- SPPN	Southwest Power Pool/North	Northern Great Plains
20- SRSG	WECC/Southwest	Southwest
21- CANO	WECC/CA North	Northern California
22- CASO	WECC/CA South	Southern California
23- NWPP	WECC/Northwest Power Pool	Northwest
24- RMRG	WECC/Rockies	Rockies
25- BASN	WECC/Basin	Great Basin

Electricity Market Module Regions

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Research on Price of Generation Factor

- Purchase price being $110.80 Dollars/MWH (for customers)
- Cost to produce being $17.40 Dollars/MWH (for utility company)

$93.40 Dollars/MWH Profit

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Solar Field Rating	% Average Capacity	Average Capacity	Sunshine Per Year	Life Time	Life Time	Life Time	New Mexico Electricty Cost	Price of Generation Factor	Generation Revenue	Annual Revenue	Construction Cost	O&M Costs	Salvage Value
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6			Based on Last Years Group %	*If we bump up rat	*This value might need changed				Souce Found From (10/21/2024)	Souce Found From (10/28/2024)					
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15		Cents	#VALUE!												
16		kWH:	5070600000												
17															
18		Cents/kWH	#VALUE!												

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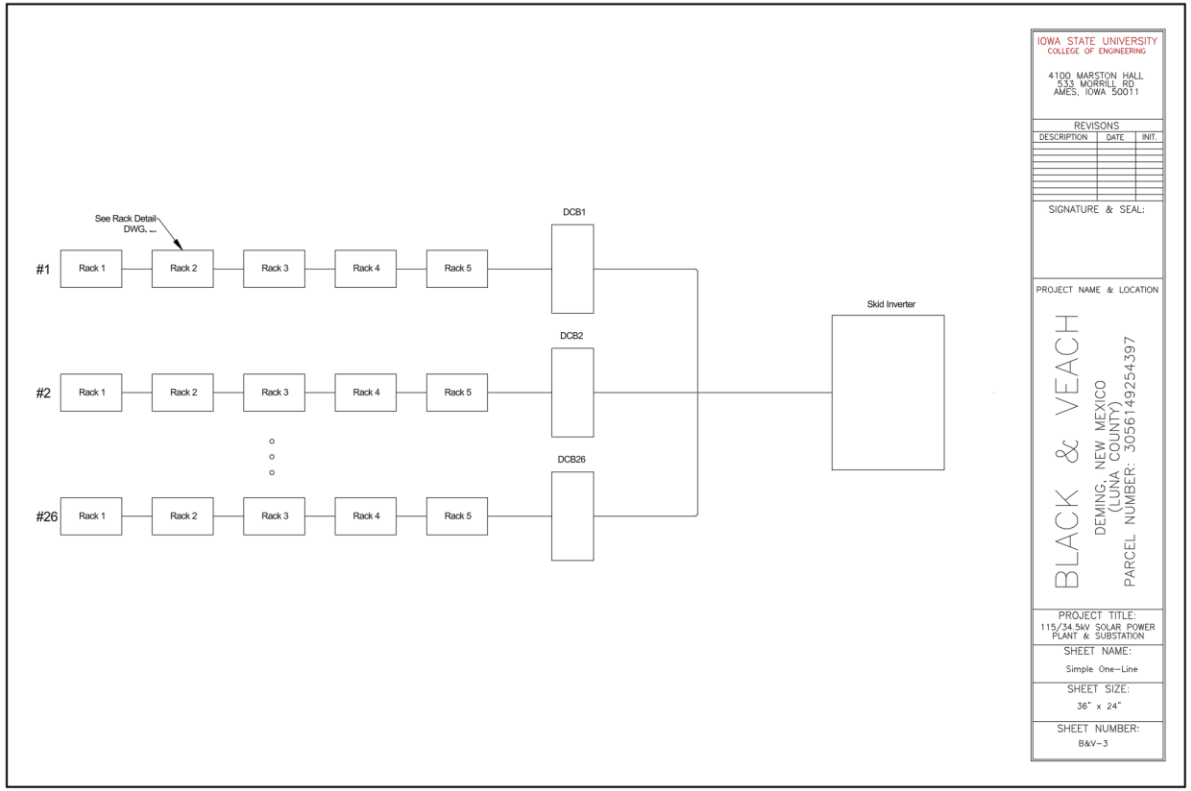
Simple One-Line

- Took details out to make it easier to understand.



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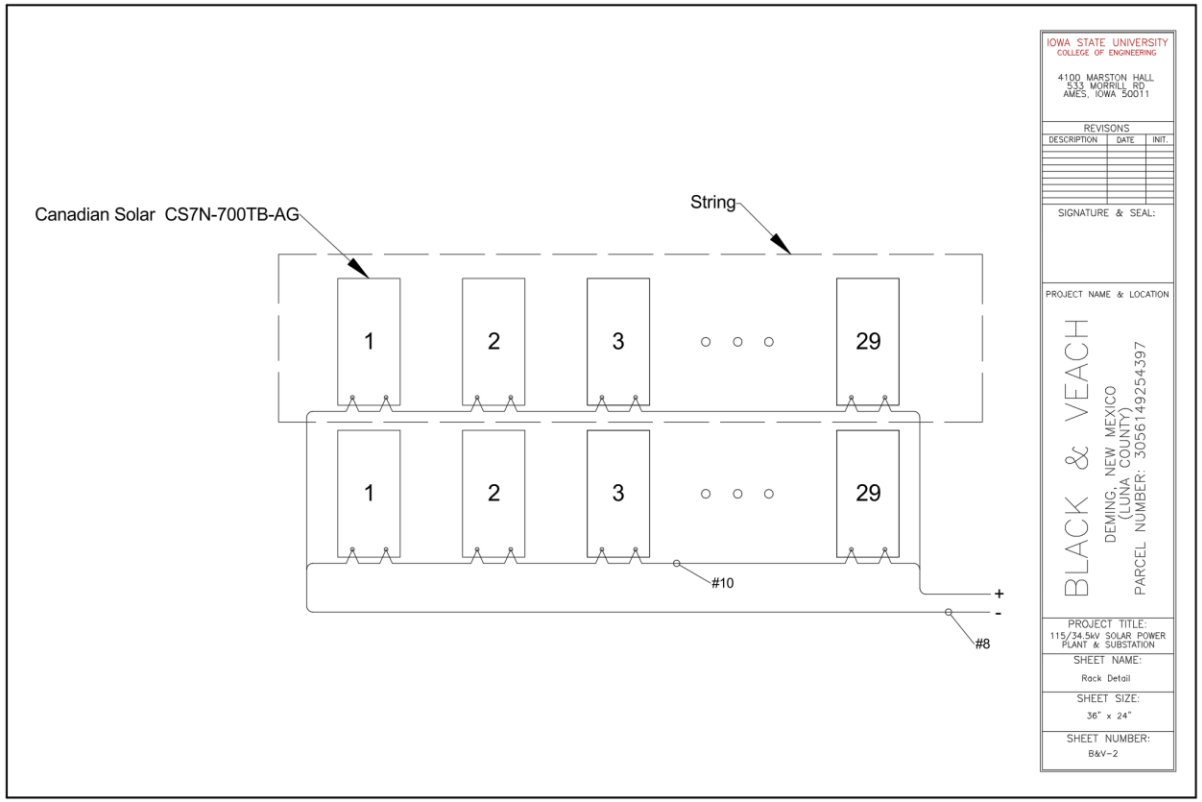
Rack Details

- Added the details on a separate drawing



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THANK YOU

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