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115/34.5kV Solar Plant & Substation Senior Design Project

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| Senior Design Team 41

| 10/10/2024

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AGENDA

- Safety Moment
- New Technology
- Expand on Cost Estimations
- Drawings for Project
- Further Discuss the Array Parameter Tool – Tilt, Voc
- Cost Analysis using high-efficiency solar panels on less land vs. Using less-efficient solar panels on more land

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Safety Moment

- **Electrical Safety for PV Installation**

1. Find all the overhead power lines. Before you start any installation, you should find all the power lines in the area so that you don't touch them by chance. To make sure everyone is aware, use site maps and visual checks.

2. Consider all overhead lines live and dangerous, even if they don't look like they're doing anything. This way of thinking keeps workers alert around electrical dangers and keeps them from getting too comfortable.

3. **Keep a 10-foot distance**: Keep at least 10 feet between you, your tools, and any power lines that are above you. This space helps keep people from accidentally touching, which could hurt or kill someone.

4. Move ladders and other long items horizontally. To avoid touching power lines by mistake, move ladders, poles, and other long items horizontally when moving them on the ground.

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New Technology

Solar Tracker

Definition: A solar tracker is a device that moves solar panels to follow the sun's path across the sky.

- **Types of Movement**

Single-Axis Trackers: Move in one direction (east to west).

Dual-Axis Tracker: Move in two directions (north-south and east-west), following the sun more precisely.

- **Benefits of Solar Trackers**

Increased Energy Production: Trackers increase solar energy production by up to 30-40% compared to fixed panels.

Better Efficiency: Trackers ensure optimal solar exposure throughout the day.

Reduced Land Usage: More efficient energy production means less land needed for solar farms.

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Availability of Workload

- Skilled workforce.
- Contractor and Supplier Network.
- Local Government Support.

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Tilt

- The following tilt degrees are for Albuquerque/ New Mexico Area based on latitude
- Fixed Tilt/ Year Round: 29.8 degrees
- 2 Season Tilt: winter at 50 degrees and summer at 11.6 degrees
- 4 Season Tilt: winter at 55.2 degrees, summer at 8 degrees, and the fall and spring season are 32.1 degrees
- Panels will be facing south for maximum output

- https://www.solarpaneltilt.com/
- https://solarific.co/us/nm/albuquerque#:~:text=4%2DSeason%20tilt,in%20autumn%20and%20spring%20months.

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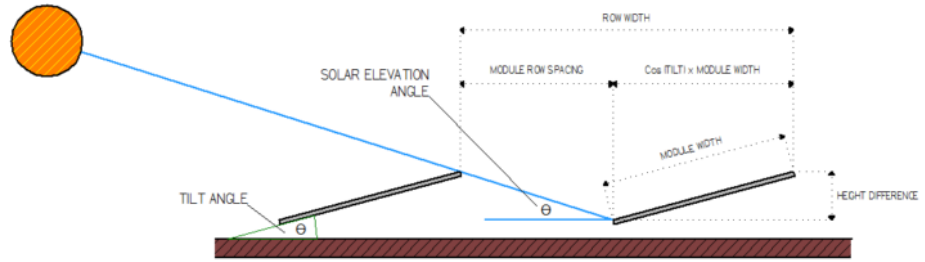
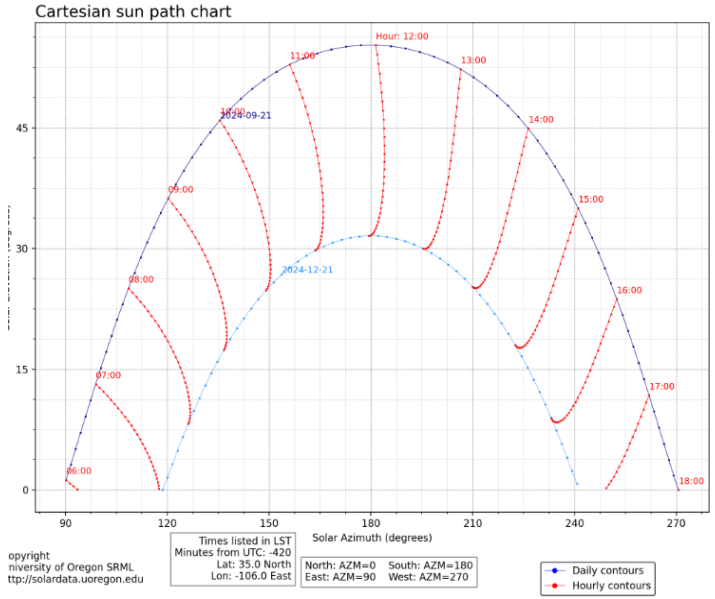
Tilt and Row Spacing



Height Difference = Sin (Tilt Angle) x Module Width

- Module Row Spacing = Height Difference / Tan **30**
- Minimum Module Row Spacing = Module Row Spacing x Cos (Azimuth Correction Angle)



https://www.greentechrenewables.com/article/determining-module-inter-row-spacing

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Array Parameter Tool

		String Size				Electrical Rack Size				CB capacity				Array Design				Array Size		
					Designer Choice		Landscape													
	Location Dependent	Min Temp	4.44	C	Datasheet	Module width	7.82	ft	Datasheet (STC)	mod/string Isc	18.49	A	Designer Choice	Racks per row	26	Designer Choice	tilt	30	
					Datasheet	module height	4.27	ft	NEC sectic	multiplier	1.25								
	Datasheet (STC)	Voc	47.9	V						nom Isc	23.1125		Designer Choice	rows per Array	5		table height proj	7.395857	ft
	Datasheet (STC)	Ref temp	25	C	Designer Choice	Rack width	29	modules	Irr.	multiplier	1.25								
					Designer Choice	Rack height	2	modules		max Isc	28.89063	A	Designer Choice	Racks removed	0	Designer Choice	row space	9	ft
	Datasheet	Temp Coeff of Voc	-0.0029	/C		Modules per rack													
		Temp delta	-20.56			Rack width	226.78	ft	Designer Choice:	allowed current	320	A		Total Racks/Array	130		pitch	16.39586	ft
		temp correction	1.06			Rack height	8.54	ft	200,	is this disconnect A?							Space for Inverter Maintenance		ft
		V0c corrected	50.75599						400A etc.	strings per CB	11.07626			Total modules	7540		Array height	81.97928	ft
										Round down:	11								
Confirm possible with Panel type chosen		string voltage	1500	V						racks per CB	5.5		Datasheet (STC)	module capacity	700	W	Array width	5896.28	ft
	Designer Choice: 600, 1000, 1500, 2000V	String size	29.55316														Ground Coverage Ratio	0.520863	
		string size	29											dc capacity	5278	kW			
		Actual String Voltage	1471.9										Designer Choice	inverter capacity	4095	kW			
																MVA			
													Provided:	ILR	1.288889				
		Input Information =											Industry standard 1.3						

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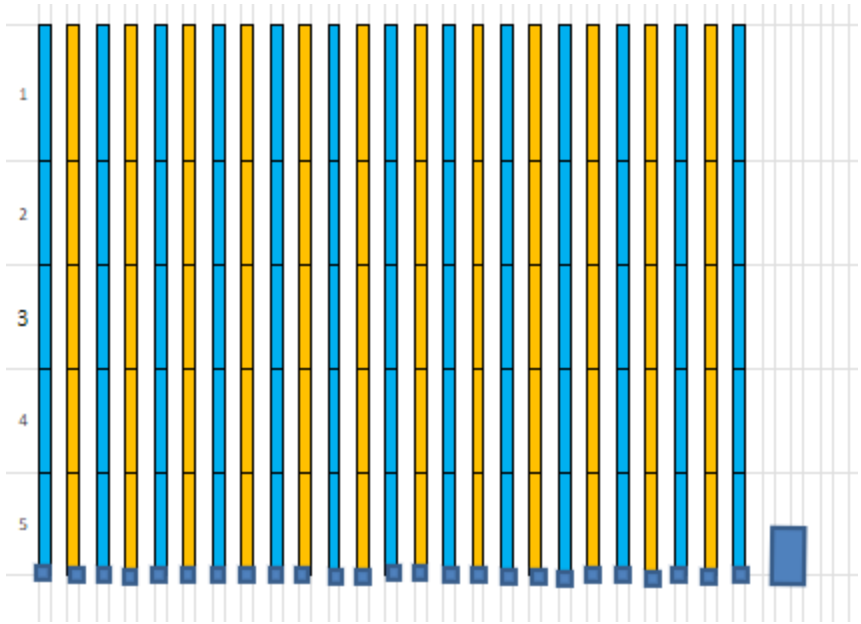
Array Model



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Array Model

- 1 array takes up around 11.09 acres of land
- Need 14.65 arrays in order to reach 60 MW of production
- Need around 162 acres in total for the solar field

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Selection of PV Module, Combiner Box, and Inverter

1. PV Module

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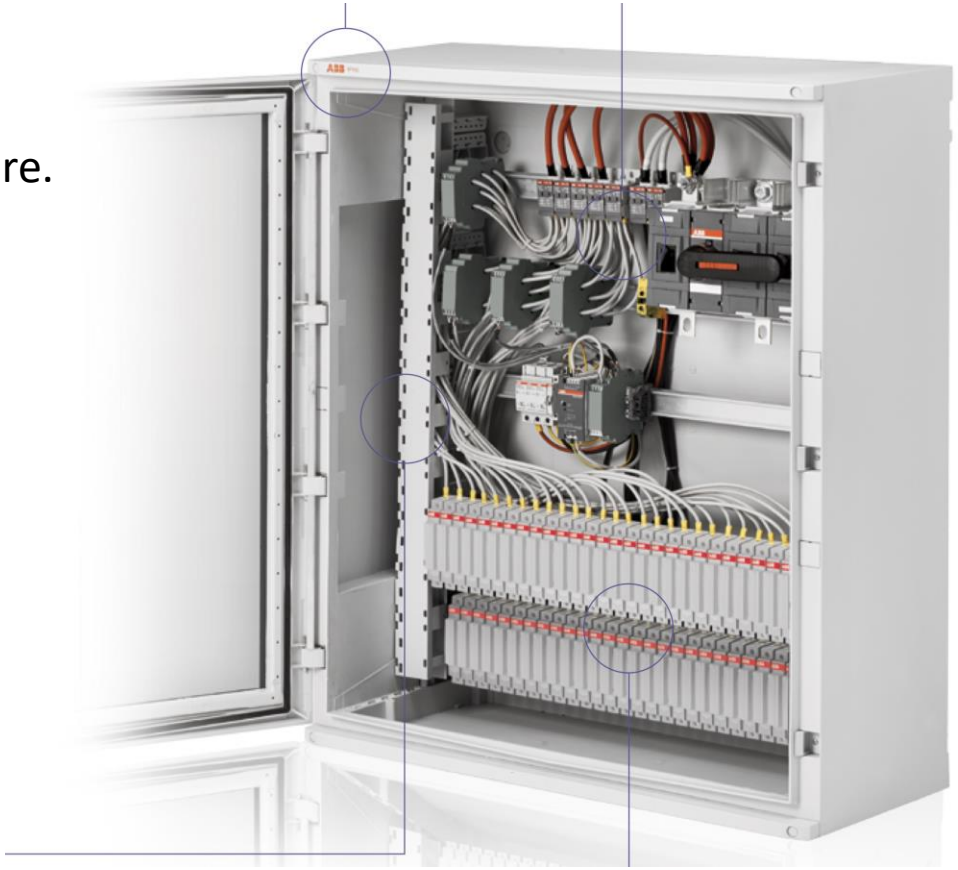
Selection of PV Module, Combiner Box, and Inverter

2. Combiner Box

- NEMA 4 outdoor-rated enclosure.
- High Current ratings.
- Utility-scale.
- High Protection Standards.



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Selection of PV Module, Combiner Box, and Inverter

3. Inverter

- High Efficiency.
- Large Power Capacity.
- Low total Harmonic Distortion.
- Versatility and Scalability.

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COST ESTIMATION

- Solar cells

$ 250 per panel

  - 7540 panels total
  - $1,885,000

- Combiner boxes
- Skids
- Land: 162 Acres, $ 2,000 per acre
- Cables
- Labor

• Average Salary in New Mexico: $ 18-24 per hour per worker
• Workday: 8 hours
• 6+ months for labor

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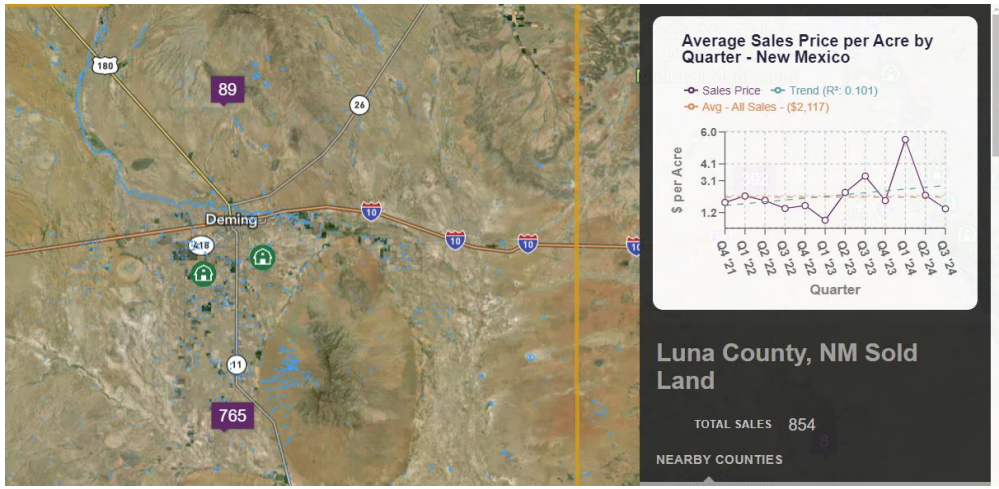
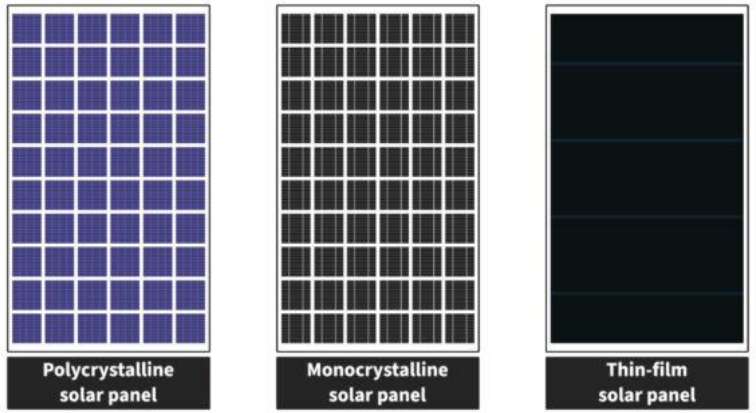
Cost Analysis – Comparing price of highly-efficient & less-efficient solar panels vs. land cost in NM

Luna County, NM

- Average Sale Price: Around $2,000 per acre



- **Monocrystalline Solar Panels**:
  - **Land Required**: Approximately 162 acres
  - **Land Cost**: Approximately $324,000
- **Polycrystalline Solar Panels**:
  - **Land Required**: Approximately 198 acres
  - **Land Cost**: Approximately $396,000
- **Thin-Film Solar Panels**:
  - **Land Required**: Approximately 320 acres
  - **Land Cost**: Approximately $640,000



https://www.acrevalue.com/sold-land/NM/Luna/?lat=32.18734&lng=-107.764004&zoom=9

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Cost Analysis – Comparing price of highly-efficient & less-efficient solar panels vs. land cost in NM

	Monocrystalline	Polycrystalline	Thin-film
Efficiency	**Over 20%**	15% to 17%	7% to 13%
Cost (Per Watt)	**$1.00/Watt to $1.50/Watt**	$0.90/Watt to $1.00/Watt	$0.70/Watt to $1.00/Watt

- For a 60MW Solar farm:
- 1 MW = 1,000,000 Watt
- 60 MW = 60,000,000 Watt

- Monocrystalline is most efficient and will take significantly less land, up to ½ of land compared to thin-film panels to produce 60MW

- Other Important Factors:
  - Installation Costs (more panels will increase labor costs)
    - Almost double the amount of labor for Monocrystalline vs. Thin Film
- Long Term Costs
  - Maintenance for more # of panels
  - Property Taxes for more land
  - Less efficient panels degrade faster
- Monocrystalline technology is better at producing under shaded conditions compared to other types
  - Greater yield over time ~ more profitable $$$

https://www.thisoldhouse.com/solar-alternative-energy/reviews/monocrystalline-vs-polycrystalline-solar-panels
https://www.ecowatch.com/solar/thin-film-solar-panels

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THANK YOU

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