34.5/115 kV Solar Power Plant & Substation Senior Design Project

Senior Design Team 18 - May 2024

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BLACK & VEATCH

Agenda

- Safety Moment
- PV Cell Cutsheets
  - Array Tool
- Combiner Box Cutsheets
- Skid Cutsheets
- Location
  - IA
  - NM
  - Comparison

Safety Moment - Personal Protective Equipment

Why is it important?

- Prevent personal injuries/fatalities
- Protect equipment from improper use
- Ensures minimal exposure to hazards

What to use and when to use it

- Hard hats should be worn in active construction sites as well as sites with overhead equipment or potential falling debris
- Steel toe boots should be worn in active construction sites as well as in environments where there is a reasonable expectation of hazardous walkways
- Arc flash/fire retardant suits should be worn when handling energized high voltage equipment

PV Cell Cutsheets

Ziegler CAT PVC380 Solar Panel Max Power: 380 W Voc: 49.0 V Isc: 9.96 A Efficiency: 19.0%

https://www.zieglercat.com/assets/files/LEHE1875-00-HTS-PVC380-MP03-H-1500V-35mm-panels-English.pdf

** SunPower E-Series Commercial Solar Panel Max Power: 435 W Voc: 85.6 V Isc: 6.43 A Efficiency: 20.3%

https://us.sunpower.com/sites/default/files/media-library/data-sheets/sunpower-e-series-commercial-solar-panels-e20-435-com-datasheet-521912-revb_1.pdf

Renogy X Commercial Solar Panel Max Power: 550 W Voc: 49.95 V Isc: 14.05 A Efficiency: 21.3%

https://23674223.fs1.hubspotusercontent-na1.net/hubfs/23674223/Renogy%20X%20Module%20CAI%20Spec%20Sheet-1.pdf

Array Tool

		String Size				Electrical Rack Size					CB capacity				Array Design				Array Size	
					Designer Choice		portrait or Landscape													
	Location Dependent	Min Temp	-45	C	Datasheet	Module width	7.475	ft	Datasheet (STC)	mod/string Isc	14.05	A	Designer Choice	Racks per row	20	Designer Choice	tilt	10	
					Datasheet	module height	3.72	ft	NEC sectio	multiplier	1.25								
	Datasheet (STC)	Voc	49.95	V						nom Isc	17.5625		Designer Choice	rows per Array	91		table height proj	7.32697	ft
	Datasheet (STC)	Ref temp	20	C	Designer Choice	Rack width	30	modules	Irr.	multiplier	1.25								
					Designer Choice	Rack height	2	modules		max Isc	21.95313	A	Designer Choice	Racks removed	0	Designer Choice	row space	7	ft
	Datasheet	Temp Coeff of Voc	-0.0026	/C		Modules per rack													
		Temp delta	-65			Rack width	224.25	ft		allowed current	250	A		Total Racks/Array	1820		pitch	14.32697	ft
		temp correction	1.17			Rack height	7.44	ft	Designer Choice:	is this disconnect A?							Space for Inverter Maintenance		ft
		V0c corrected	58.39155						200, 400A etc.	strings per CB	11.3879			Total modules	109200		Array height	1303.754	ft
										Round down:	11								
Confirm possible with Panel type chosen		string voltage	1500	V						racks per CB	5.5		Datasheet (STC)	module capacity	550	W	Array width	4485	ft
	Designer Choice: 600, 1000, 1500, 2000V	String size	25.68865														Ground Coverage Ratio	0.5193	
		string size	25											dc capacity	60060	kW			
		Actual String Voltage	1459.8										Designer Choice	inverter capacity	100	kW			
																MVA			
													Provided: Industry standard 1.3	ILR	600.6				
		Input Information =																	

Combiner Box Cut-Sheets

**** SolarBOS Disconnect Combiners**

Max Rated Current: 200-320 A

Number of Inputs: 8-20 or 12-28 input circuits

Number of Outputs: 1 or 2

https://www.terrasmart.com/wp-content/uploads/2021/10/SS03-SolarBOS-1000VDC-Disconnect-Combiners.pdf

String combiner 1000V DC

Max Rated Current: 10-320A (customizable)

Number of Inputs: 1-32

Number of Outputs: 1 (does not say more than 1)

https://library.e.abb.com/public/48a47bf5b1fb4f70a81b1aad7f395648/1SLC009000D0202%20TC%20COMBINER%20RANGE.pdf

PVS-16MH/18MH/20MH/24MH

Max Rated Current: 336-372A

Number of Inputs: 16-24 inputs

Number of Outputs: 1

https://info-support.sungrowpower.com/application/pdf/2022/04/21/DS_20220214_PVS-16MH_18MH_20MH_24MH_Datasheet_V18_EN.pdf

Inverter Skid Cut-sheets

FIMER's PVS980-CS-US compact Skid:

Input: Max. DC Voltage = 1500V, MPPT(VDC) =_____, Number of DC input = 24

Output: (50℃/35℃) Rated Power = 2000kVA/2200kVA, AC Current = 1750A/1925A, Voltage = 660V, Max. Efficiency = _____

Environmental: Temp. = -20℃ to 50℃, Altitude <4000m

https://www.fimer.com/sites/default/files/FIMER_PVS980-CS_US-CompaktskidforUSmarket_US_Rev_B.pdf

TMEIC's Solar Ware Ninja:

Input: Max. DC Voltage = 1500V, MPPT(VDC) 875V-1300V, Number of DC input = 6 - 8

Output: (50℃/25℃) Rated Power = 730kW-840kW/800kW-920kW, AC Current = 702A/770A, Voltage = 600V-690V(10%, -12%), Max. Efficiency = 98.9%

Environmental: Temp. = -25℃ to 50℃, Altitude <4000m

https://www.tmeic.com/sites/default/files/assets/files/library/Ninja%20Data%20Sheet%20Mar2019-web.pdf

** Power Electronics' HEM: HEMK 690V

Input: Max. DC Voltage = 1500V, MPPT(VDC) 849V-1310V, Number of DC input = 36

Output: (50℃/40℃) Rated Power = 3190kW-3510kW/3300kW-3630kW, AC Current = _____, Voltage = 34.5kV(±10%), Max. Efficiency = 98%

Environmental: Temp. = -35℃ to 60℃, Altitude <2000m

https://www.power-electronics.co.nz/assets/brochures/20190606-SolarBrochure-v11.pdf

Solar Energy Industry in Iowa

- Ranked 33rd (2023), with installation over 13177 with a total power of 686MW to supply energy to 85,987 homes in Iowa.
- Growth Projection is estimated to be 1442 MW over the next 5 years
- State investment up to $975 Million
- The first operable utility-scale solar photovoltaic power plant in Iowa was established in 2016 (USEIA 2021). Between 2016 and November 2021, nine utility-scale solar photovoltaic power plants came into operation and aggregated a total nameplate capacity of 118 MW.

Notable Solar Installation

1. Wapello Solar in Wapello, IA - produce 128 MW power to supply electricity to 16605 homes
2. Strawberry Point - among largest installation with capacity to power 154 homes with 1MW
3. Arbor Hill Solar in Greenfield, IA - capable of powering 4135 homes at 31.8MW

The largest is the 3.8 MW_{AC} West Dubuque Solar Garden commissioned for Alliant Energy in September, 2017.[8]

Tax incentives make solar energy in Iowa even more attractive. Right now, a combination of federal and state tax credits provides savings of nearly 45%:

- **Federal tax credit**: 30% reduction in total costs
- **State tax credit**: 15% reduction in total costs

https://www.seia.org/state-solar-policy/iowa-solar

Geographical and Environmental Factor of IA

- Sunlight

State Sunlight Rank: 26/50
Average Annual Sunlight Hours: 2600 hours
Clear Days: 105 days per year
Summer Peak Sun Hours: 5.05 hours per day
Winter Peak Sun Hours: 2.99 hours per day
Average Peak Sun Hours : 4.55 hours per day

In Iowa, on average, we see about 4.5 daily hours of “good sunlight.” The summer months are obviously the best time, but the winter months still offering plenty of sunlight. Germany – which is on the same latitudinal plane as Iowa, sharing the same solar resources – has the most solar capacity of any European country.

- Flat Terrain

Iowa's relatively flat terrain provides ease of construction and installation for solar panels. This helps optimize the efficiency of solar arrays.

- Agricultural Land Use: The state has a considerable amount of open land, including farmland, which can be repurposed for solar installations. This dual-use approach, known as agrivoltaics, allows landowners to continue agricultural activities beneath or around solar panels.

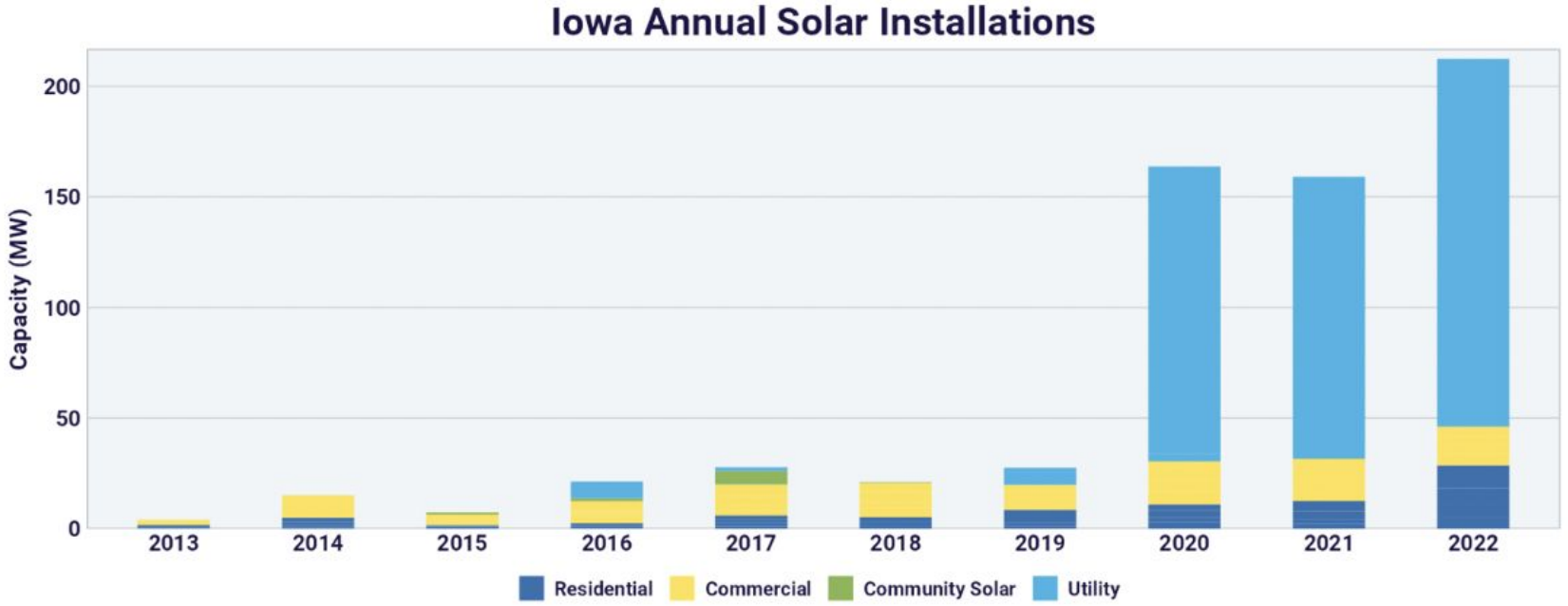
Geographical and Environmental Constraint of IA

Seasonal Variability: Iowa experiences seasonal variations in solar radiation, with reduced sunlight during the winter months. Energy storage or backup generation may be necessary to maintain a consistent power supply.

Land Use Conflicts: Competition for land between solar installations and agriculture could arise. Careful planning and land-use policies are essential to address these potential conflicts.

Regulatory Hurdles: While Iowa has been supportive of renewable energy, regulatory and permitting processes can still be time-consuming and complex. Developers need to navigate these requirements effectively.

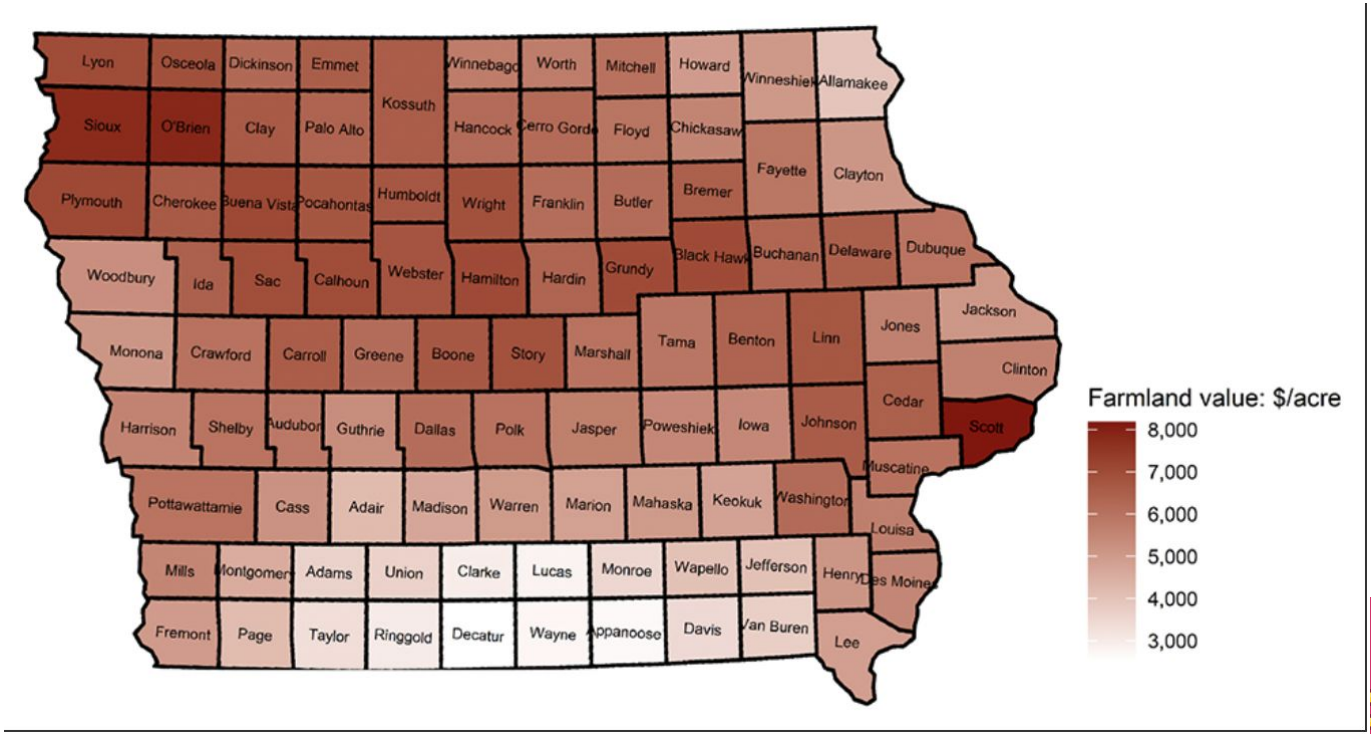
Installation in Iowa



https://www.seia.org/state-solar-policy/iowa-solar

Farm/Land Value across Iowa

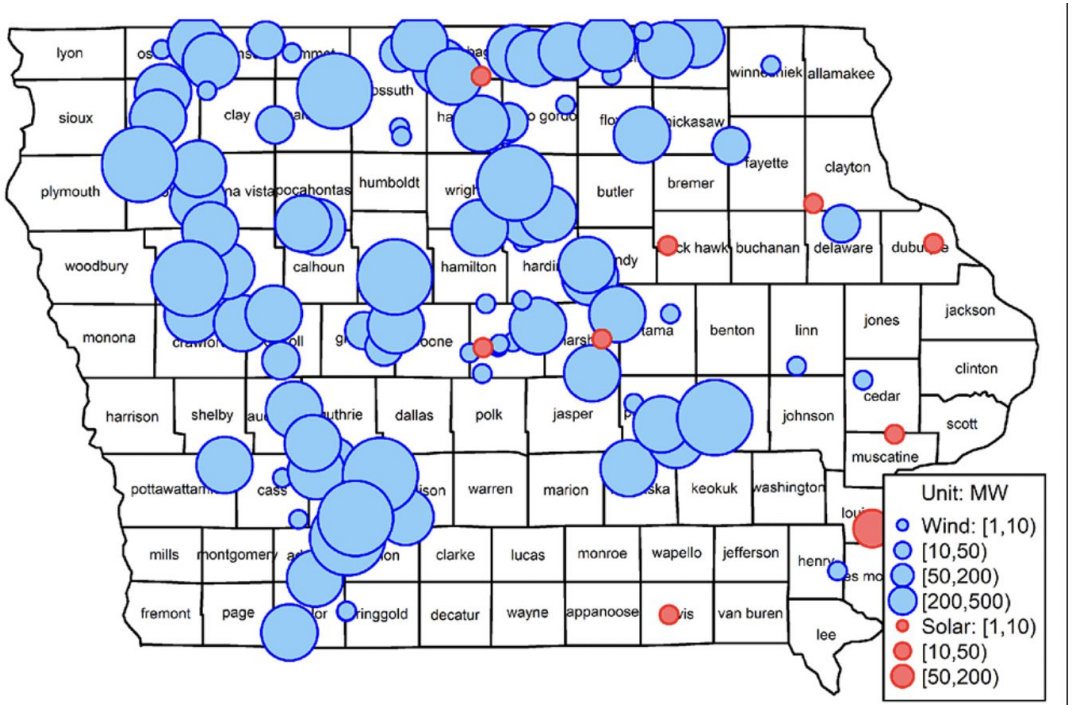
average farmland value by county from 2000 to 2021.



https://www.card.iastate.edu/ag_policy_review/article/?a=135

Solar Power Plant Location across Iowa

9 utility scale Solar Power Plant across Iowa, data last updated on 2022.



https://www.card.iastate.edu/ag_policy_review/article/?a=135

Solar Energy in New Mexico

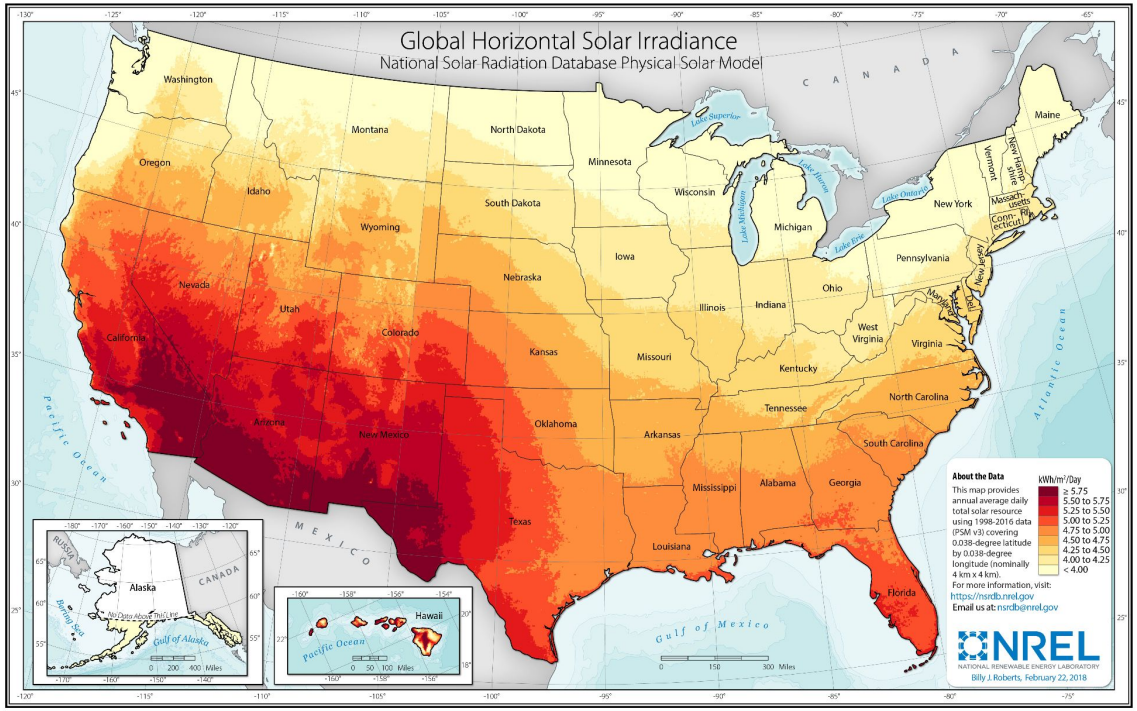
Environmental Factors

- New Mexico is 4th in the US for sunlight exposure year round
- New Mexico ranks #3 in the nation for solar power generation potentials
- Mean average temperature at lower elevation regions is around 64 degrees
    - More durable solar panel technology doesn't hinder hot days in the summer as badly
- In the northern mountains and valleys mean temperature is 40 degrees
    - Higher elevation provides more intense sunlight but lower average temperatures

Economical Factors

- New Mexico Solar Tax Credit
- Rebate Incentives
- State Grants
- As new technology appears cost of solar panel prices decreases
- Solar Panel Costs: Ranges from $2.79 to $3.77 per watt

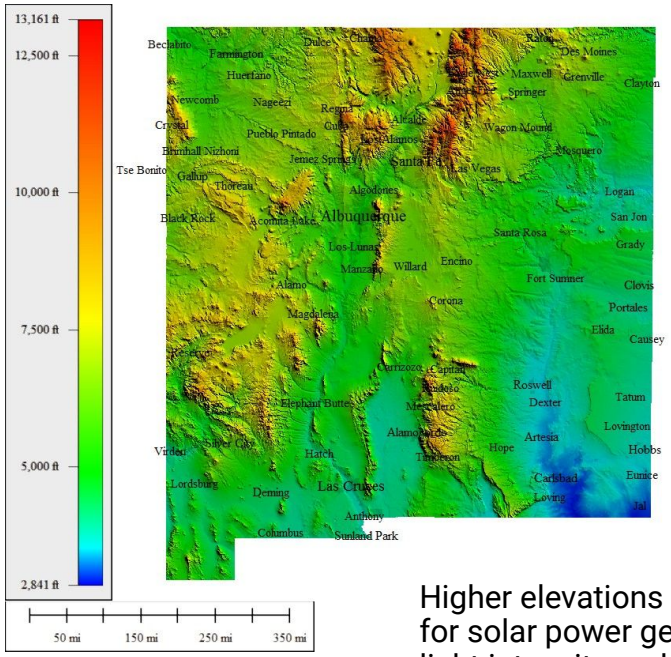
Solar Energy in New Mexico



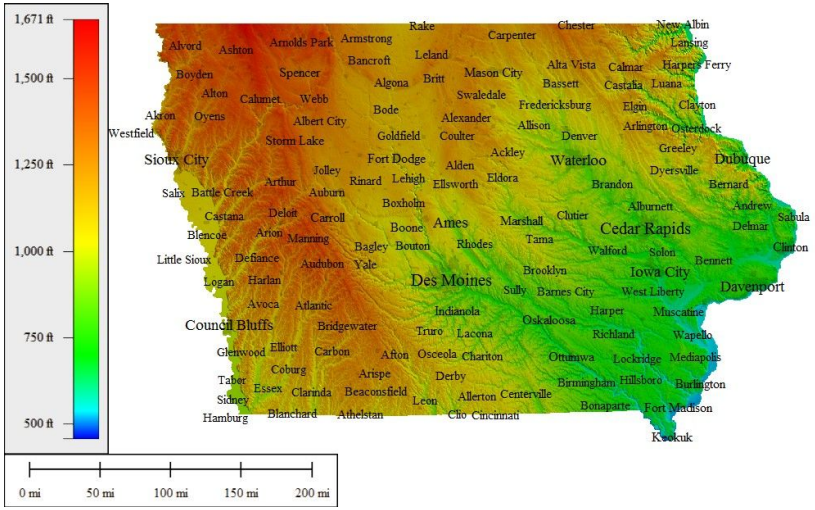
https://www.nrel.gov/gis/solar-resource-maps.html

Location Comparison - Elevation

New Mexico



Iowa



Higher elevations provide a more ideal location for solar power generation because of the higher light intensity and lower average temperature.

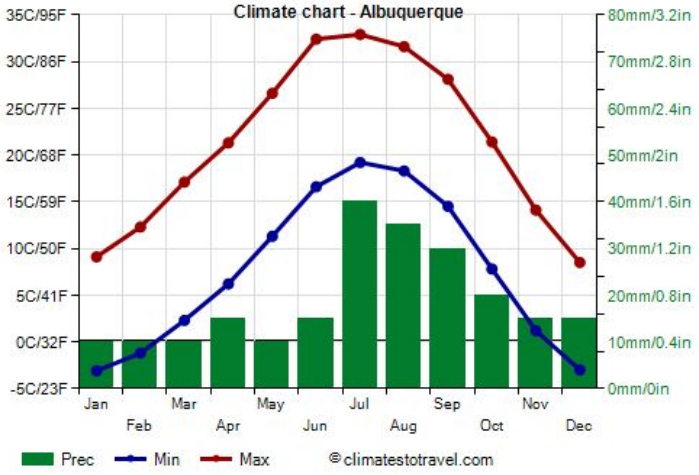
* Not the same scale on each graph

https://topocreator.com/cart.php?add=nm&mt=city_a&res=30m_st_tif&ret=NM

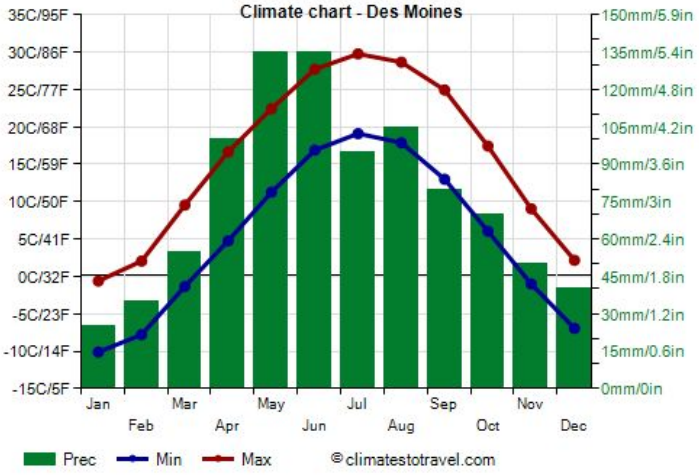
https://topocreator.com/cart.php?add=ia&mt=city_a&res=30m_st_gmg&ret=IA

Location Comparison - Average Temperature

New Mexico



Iowa



Lower temperatures make for better solar power production.

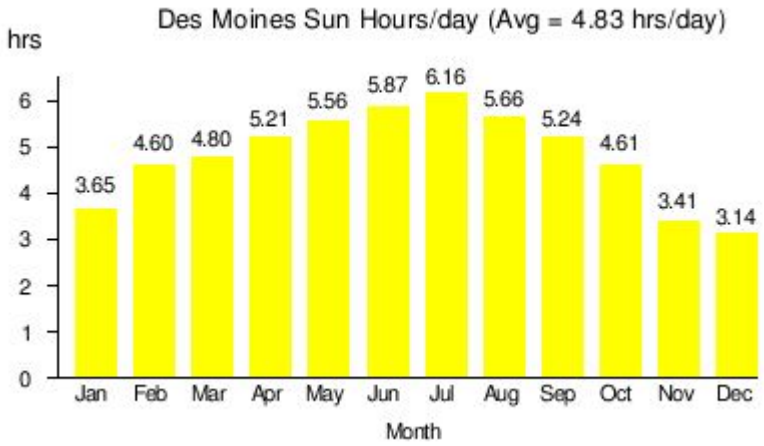
https://www.climatestotravel.com/climate/united-states/albuquerque

https://www.climatestotravel.com/climate/united-states/des-moines

Location Comparison - Peak Hour

New Mexico

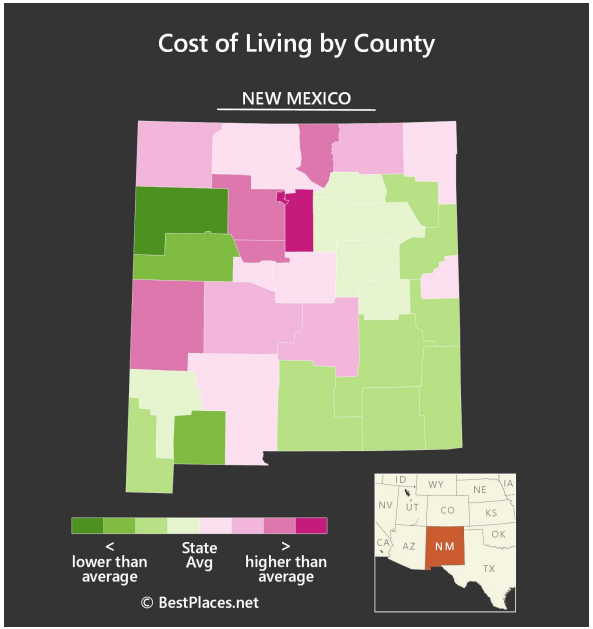
Iowa



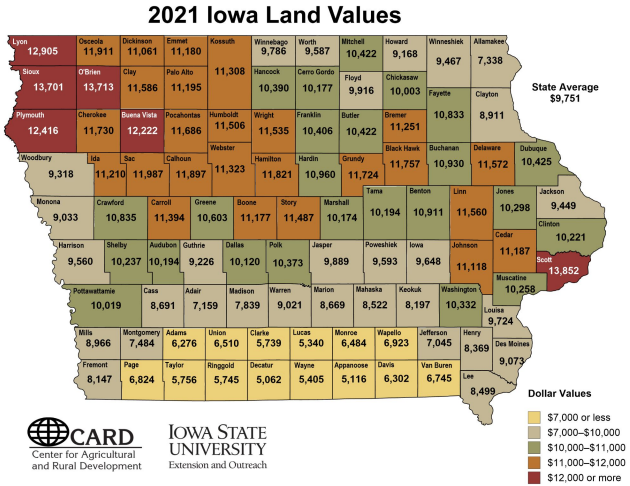
A peak sun hour is defined as one hour in which the intensity of solar irradiance (sunlight) reaches an average of 1,000 watts (W) of energy per square meter (roughly 10.5 feet). Another way to put it: A peak sun hour is the equivalent of 1000 W/m² of sunlight for an hour.

Location Comparison - Average Land Cost

New Mexico



Iowa

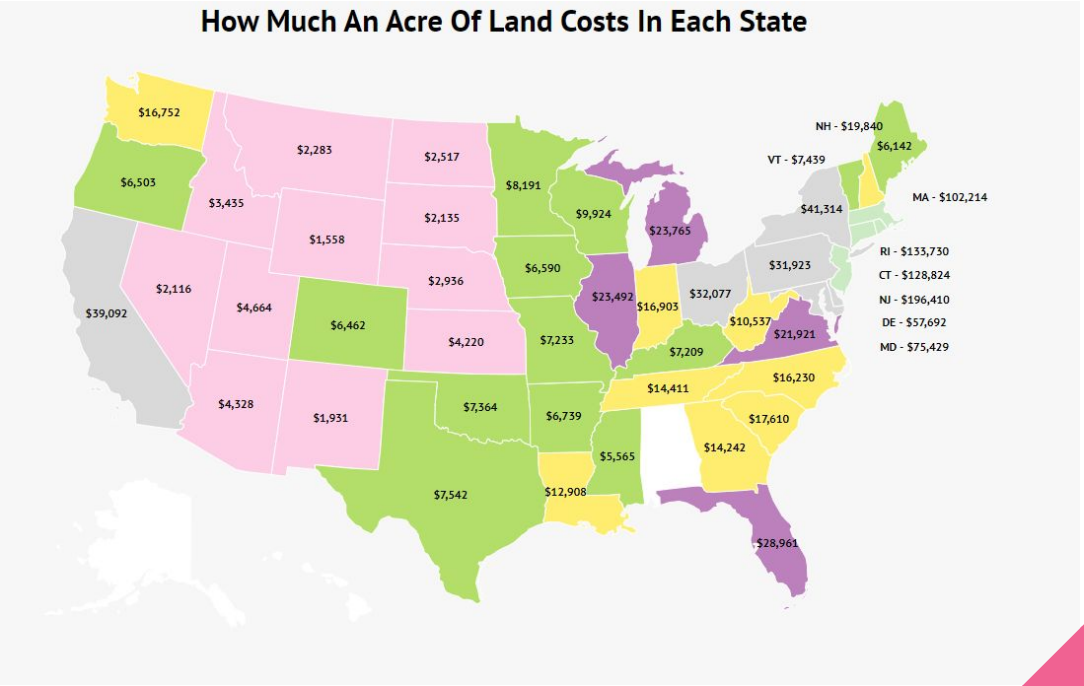


Land costs to look into for project budget and ensuring a profit margin on the project.

https://www.bestplaces.net/state/new_mexico

https://www.desmoinesregister.com/story/money/agriculture/2021/12/14/iowa-farmland-value-increase-iowa-state-university-report-acre-prices-2021/6496341001/

National Average Land Cost



https://www.theceshop.com/agent-essentials/blog/finding-your-niche-buying-and-selling-land-in-new-mexico

Update

Array tool - Liam
Sizing - Baylor
Outputs - Eduardo & Chicheng
Equipment - Eduardo & Chicheng
Cost - Eli ask Eduardo for help
Location - Bell

Next Action Item

Submit Array Parameter tool

- PV cell
- Array, string, rack sizing
- Electrical DC and AC Output
- Total Equipments
- Total Cost
- Location