AE Your Solar Solution

ATWOOD ELECTRIC
QUALITY INTEGRITY SERVICE

PV Solar

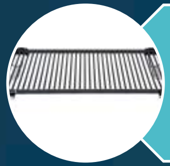
MW Design

What are you trying to accomplish?

kWh Production (Yield)	• Annual Max, Time of Day and Month of Year. • It is specific to the array latitude & longitude.
Demand Reduction	• Array azimuth (direction) affects daily peak. • Design can maximize this benefit (time of day reductions).
Reliability	• Product selection, bankability & long term performance. • Operations, Maintenance, Warranties & long term ownership

Technology Selection


What is being used in large scale solar today?


There are numerous niche technologies in modules, racking & inverters.

Is a specific cost savings worth the associated risk.


Historic performance and predictability are important.


Other speakers will cover Bankability of the manufacturers.

Racking

Fixed Tilt driven pier

- Classic large scale installation.
- Steel piles driven into the earth.
- Low installation cost, requires soils study.

Tracker

- Single or Dual axis: Increased generation
- Increased array footprint, maintenance, & cost.
- As module prices decrease, they make less sense.

Ballasted ground mount

- Land fills or poor subsurface conditions
- Concrete or rock ballast

Fixed Tilt Driven Pier Ground Mount

Single Axis Tracker

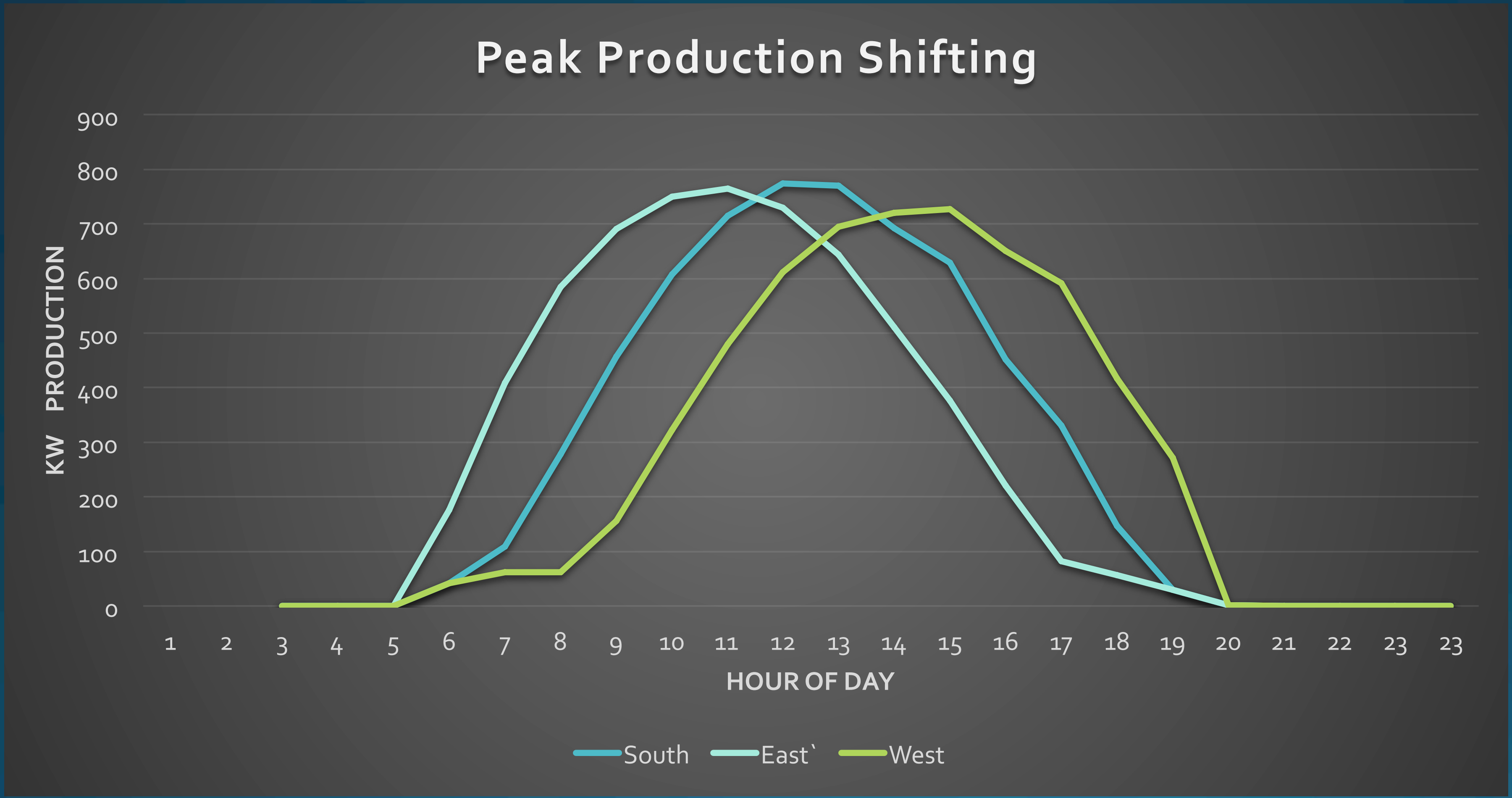
Dual Axis Tracker

Racking production comparison

100 kW (PV Watts software)	kWh (PV Watts)	% (rough comparison using PV watts)
30 Degree Fixed Tilt	141,900 kWh	100%
Single Axis Tracker	176,400 kWh	124%
Dual Axis Tracker	190,700 kWh	134%

- Parasitic loads (motor consumption if utilized)
- Increased maintenance.
- Increased installation costs.
- Larger land area for trackers to reduce shading.
- Decreasing module costs work against tracking benefits.

Effect of Array Direction on Peak Output



PV Modules (Panels)

Monocrystalline

- Highest $/watt but most efficient (~20%)
- Proven track record (since the 70's)

Polycrystalline

- Slightly less efficient than Mono due to lower silicon purity
- Most commonly used module

Thin Film

- Lowest $/watt – currently lowest efficiency but could surpass crystalline (~15%)
- Newer technology with a more complex structure

Thin Film – frameless

Modules – what affects production

Module Performance

- Temperature – the colder the better
- Irradiance – brightness of the sun

System Losses

- AC & DC line losses
- Mismatch, Soiling, Snow Cover & Shading

Angle of incidence (angle between module and sun)

- Sun path varies throughout day & year
- Modules perpendicular to the sun produce the most energy

Modules – selection considerations

Warranty

- Warranty on most modules are the same.
- 10 year physical defects.
- 20-25 year performance (80% of output).

Availability

- Can they meet your construction schedule?
- Design may vary slightly since module wattages change.

History

- What is the manufacturers track record?
- Will they be around to honor a warranty?

Inverters – converting DC to AC

String
- 24-50 kW range
- ~22 inveters in 1MW

Central
- 100kW to 1MW
- 1-4 inverters in 1MW

Micro
- 1 per module
- Not typically used in large scale solar

Inverters – Central

Inverters – String

Inverter Design Considerations

- Repair & Replacement ease.
- Lead times on new units or parts.
- Extended warranties – 10 to 12 standard, up to 25 available
- All manufacturers have had their issues, but how do they resolve it?
- DC to DC converters (SolarEdge & module integrated)

System Performance

Using Software to model expected performance.	PVSyst – utility standard for modeling .	Built by physicists in Geneva, Switzerland.
		Screening process to validate performance (modules & inverters) data.
	PAN files	These contain the data the software utilizes
		Need to be 3rd party verified.
		Black & Veatch does much of this work.
	Other Software for modeling	System Advisor Model (free, from NREL)
		HelioScope

System Performance - Variables

There are a lot of moving parts in the software packages

- There are industry accepted values.

Independent verification of PV plant production is important

- Can be self performed or hired out depending on your experience.
- I typically model in 2 software packages to compare data.

Weather data

- not all data sets are complete
- I recommend comparing nearby cities
- Micro-climates: what local or regional effects should be considered

Snow Shedding

Steeper module tilt will shed snow more quickly.

Summer production is approximately 2.5 x winter production

Higher module tilt requires larger row spacing which means more land to avoid row to row shading

Soiling & Cleaning

- Dirty modules produce less power.
- There is not a common consensus on if they should be cleaned and how often.
- Dry dusty climates tend to have a cleaning regiment
- Iowa receives enough rainfall, my opinion is to evaluate the array annually.

Electrical Losses

- Conductor losses are designed at maximum inverter output per the National Electric Code.
- Actual losses have been found do be significantly less.
- This is primarily due to the limited amount of time an inverter runs at maximum output.

Inverter Clipping Losses

- Oversizing or DC to AC ratio refer to the kW of Modules to the kW of Inverters
- This is a common design practice, the right amount depends on project specific economics.
- It can be as high as 150% in some cases, a safe ratio that works for most projects is 125%.
- The higher the ratio, the lower your $/watt of inverters, but revenue is lost as well due to increased clipping.
- The highest ROI will always have some clipping.

Performance Monitoring

- Inverter level to module level options
- 3rd party systems or inverter integrated
- Automatic fault notification
- Self monitoring or professional services
- Cloud based reporting
- Some services model expected vs. actual performance

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Questions?

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