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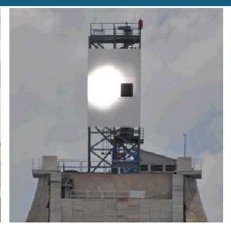
Optical Performance Modeling and Analysis of a Tensile Ganged Heliostat Concept (ES2019-3933)



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1. Retired from Sandia
2. Skysun, LLC

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Outline

- Background
- Motivation
- Optical Modeling
- Results
- Conclusions

Background

- Skysun conceived the tensile ganged heliostat concept.

- In 2017 was awarded the DOE Small Business Voucher (SBV) to get support from Sandia.
  1. Evaluate optical and mechanical performance on a small-scale prototype.
  2. Model a large-scale system and compare to standard heliostats in 10 MW plant.
  3. Perform cost study on large-scale system.

Yellowhair, Armijo, Andraka, Ortega, Clair, *Mechanical and Optical Evaluation of the Skysun Tensile Ganged Heliostat Concept*, Sandia National Laboratories SAND2017-7101.

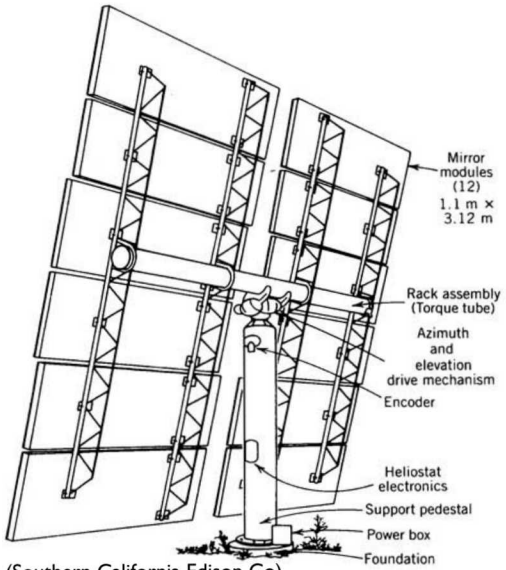
Prototype 3

Scaled down from the 10 MW concept.

Motivation

- **Power tower collector field make up 40-50% of the installed cost.**

- Standard heliostats use pedestals with independent motor drives to move the heliostat in azimuth and elevations angles to track the sun.



(Southern California Edison Co)

- With ganged heliostats components, such as the pedestal and motor drives, can be shared.

- **Due to the shared components, there is potential for cost savings and reduced LCOE.** The optical performance, however, may degrade.
  - Tracking and accurate pointing becomes difficult.

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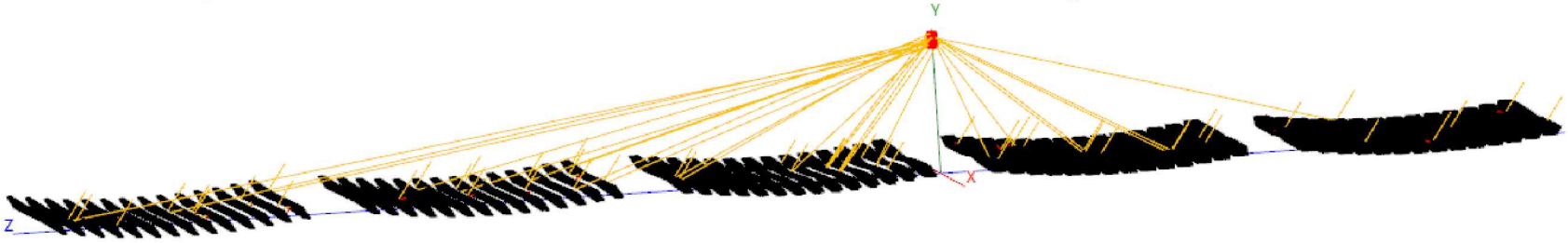
Optical Modeling Approach

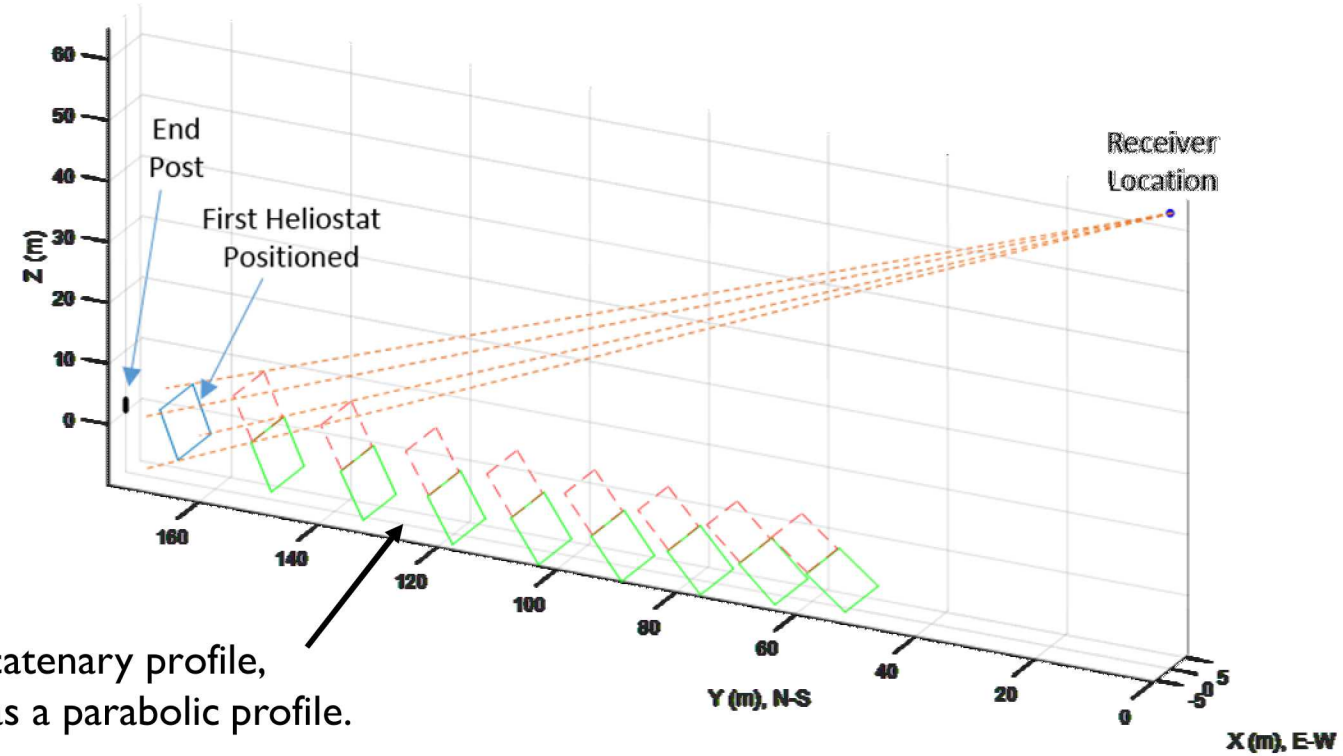
- 10 MW electric power tower model in SAM
  - Used SAM field optimizer to generate surround field with conventional heliostats
  - Used custom code to generate field layout using Skysun ganged heliostats
- Heliostat parameters:
  - 64 m^2
  - Cable span = 175 m
  - Span-to-sag ratio = 20 (sag = 8.75 m)
- Optical efficiency analysis using SolarPilot
- Field layout and irradiance at receiver evaluated using SolTrace



- Initially the heliostats had equal spacing along the span. This resulted in significant shading and blocking.

Minimizing Shading and Blocking

- Developed Matlab code to generate field layout including minimization of shading and blocking.



Span on a catenary profile, estimated as a parabolic profile.

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Optical Parameters and Results

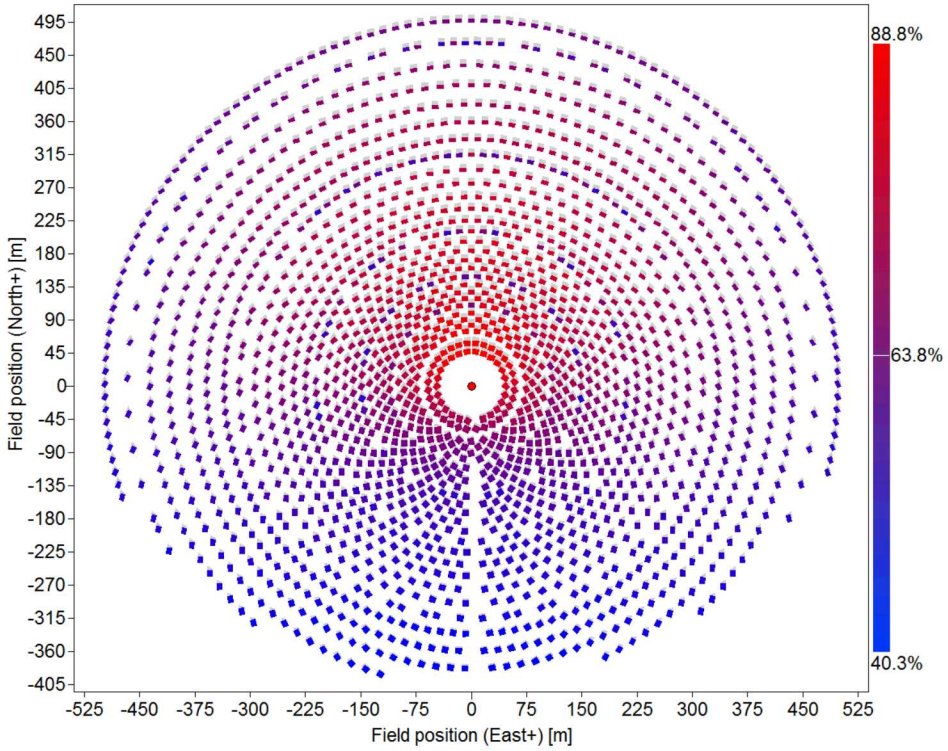
- Global optimization was not performed on the ganged heliostats. Parameters that can be optimized:
  - Tower height
  - Span
  - Span-to-sag ratio
  - Heliostat spacing
- The ganged heliostat field was evaluated with SolTrace and SolarPilot.
- Field then transferred to SAM for comparison to the conventional heliostat field.

TABLE 1. Parameters for the 10 MW_e power tower models.

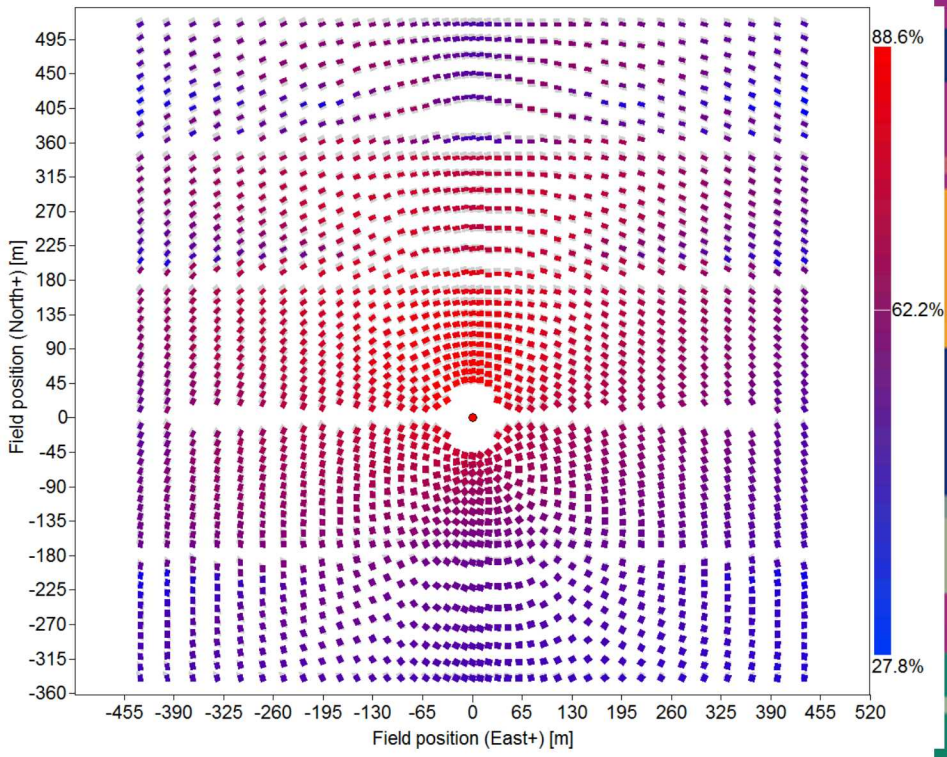
Parameter	Conventional Heliostat Field	Ganged Heliostat Field
Location (default)	Daggett, CA	Daggett, CA
Optical Slope Error per Axis (mrad)	1.53*	2
Heliostat cost ($/m^2)	120**	75***
Heliostat Reflective Area (m^2)	64	64
Mirror Reflectivity	0.9	0.9
Canting Strategy	On-Axis	On-Axis
Tower Height (m)	62.8	75

* SunShot target for optical slope error in each axis, which includes mirror slope errors, mirror canting errors, and tracking errors.
** Estimated current heliostat cost, or cost goal for 2018 Power Tower Roadmap.
*** Skysun cost estimate provided in [35].

Optical Efficiency

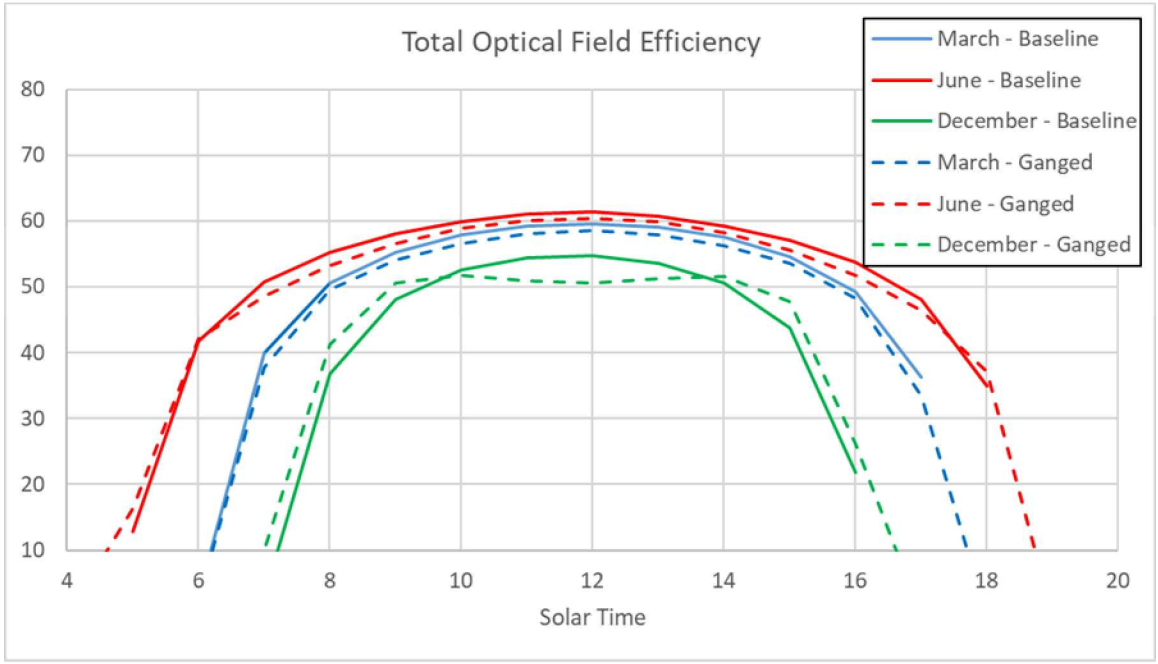


63.8% optical efficiency

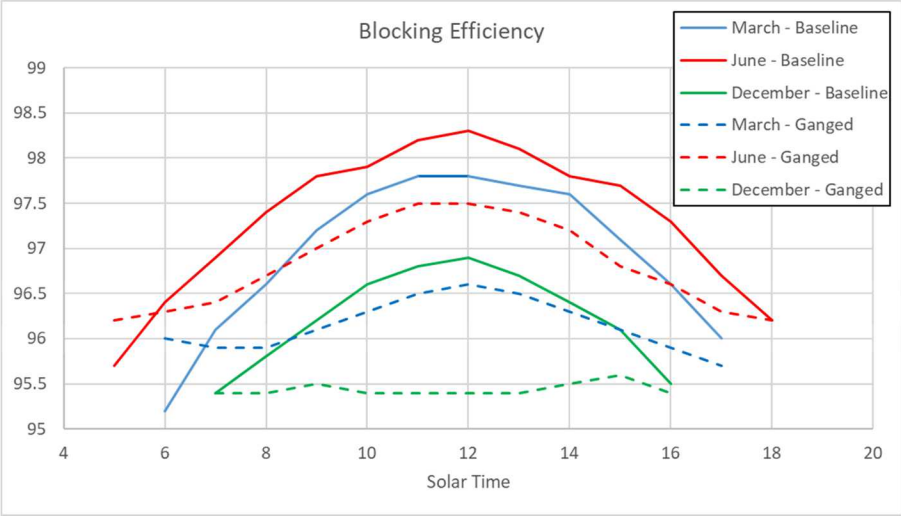


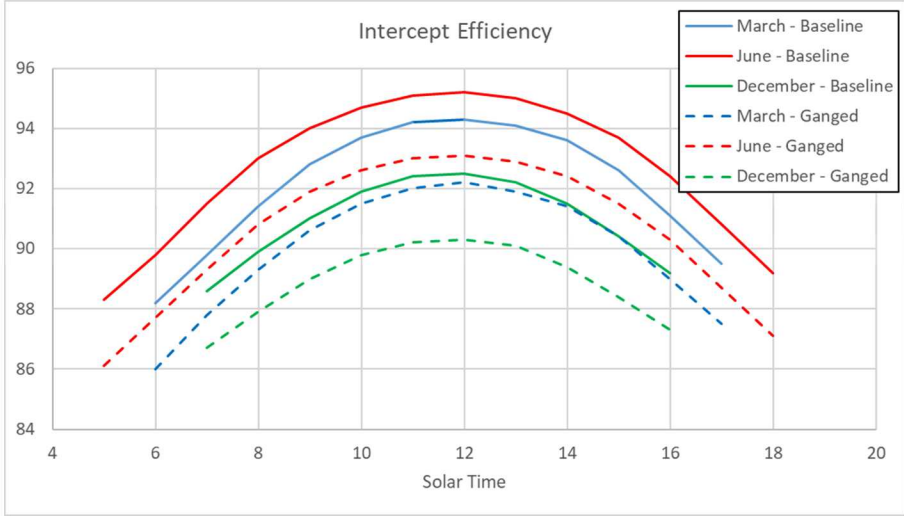
62.2% optical efficiency

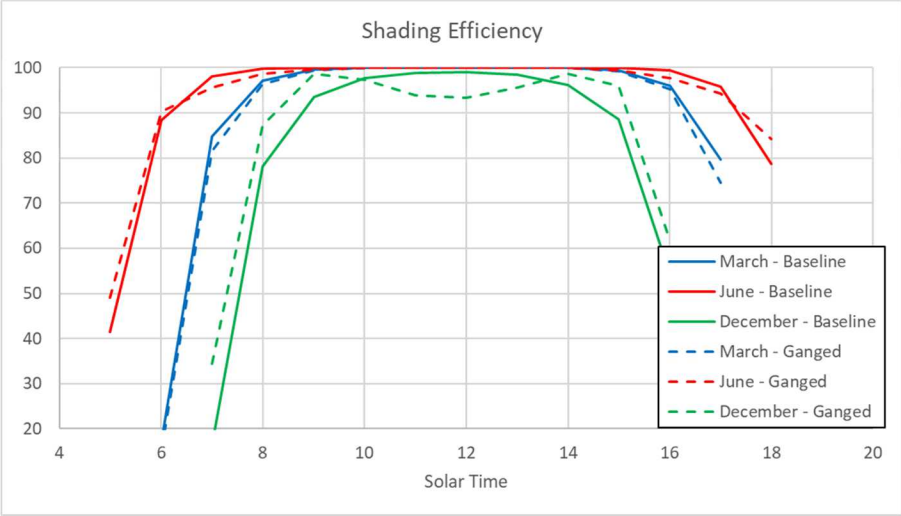
Total Optical Efficiency

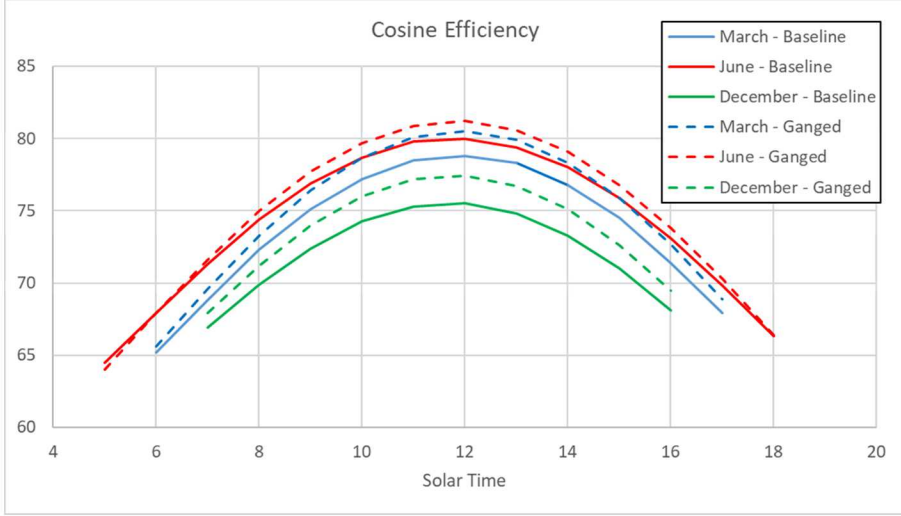


Optical Efficiency Plots



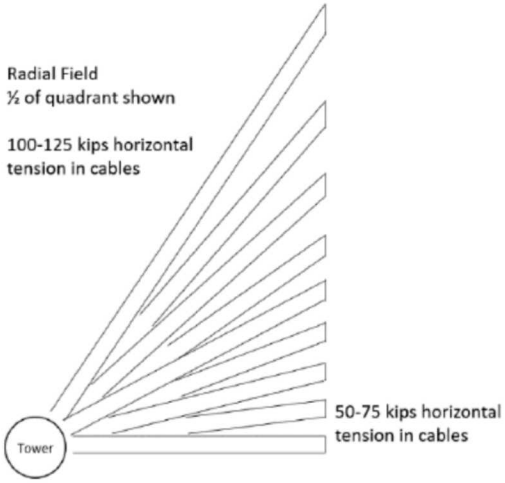




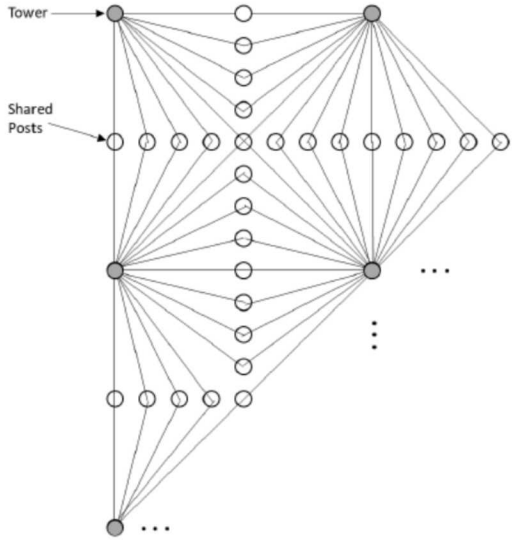


Alternative Ganged Heliostat Layouts

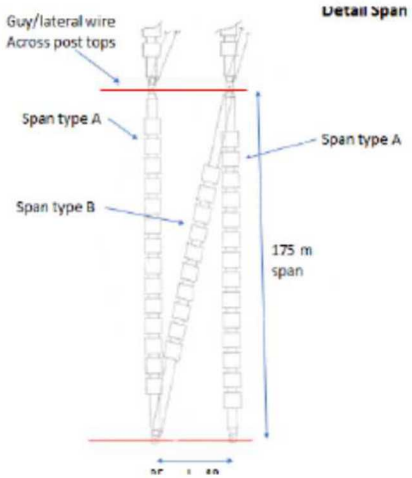
Radial Spans with Single Tower



Radial Spans with Multiple Towers



Additional Diagonal Spans



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Conclusions

- Collector field cost make up 40-50% of the plant installed cost.
- Ganged heliostat have cost advantages due to shared components.

- Evaluated the Skysun ganged heliostat design against conventional heliostat in a surround field at a 10 MW scale.
- Technoeconomics showed ganged heliostats comparable performance to conventional heliostats.
- Global optimization was not performed, which could further improve the optical efficiency and reduce cost.
- Alternative ganged heliostat layouts could further reduce cost.

Questions?

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