Variation of Heliostat Wind Loads in a Radial Field Array Model

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Introduction

• Heliostat arrangement optimised for optical performance
• Arrangement based on wind loading is not considered
• Heliostats identical in design throughout field
• Design can be optimised for location in field
• Possible for wind loading to vary across a CSP field

Crescent Dunes 110MW. Photo captured by Hegen (2016)
Question

How does heliostat wind loading vary throughout a heliostat field array?
Experimental Setup

• Circular model 2.7 m diameter
• 64 heliostats
• Four rows from centre
• 1 m tall central tower
• Central tower removable to analyse effects
• Four instrumented heliostats repositioned around field
Wind tunnel ABL generation

- Generate part depth atmospheric boundary layer (ABL)
- 9.6 m/s at hinge height
- 3 x 3 x 17 m test section
Heliostat load coordinates

- Four 3-axis ±2N load cell (K3D40)
  - Sampled at 1 kHz simultaneously
- Sheltered beneath surface
- Relocated around the field
- Adjustable about 3-axes
  - Azimuth angle (β)
  - Elevation angle (α)
  - Hinge height
Heliostat array layout

- Maximum flow speed 12 m/s
- Heliostat
  - 100 x 100 mm
  - 0.01 m²
- Radial non-blocking
  - 64 heliostats total
Configurations

- Test cases for surround field with central tower at equator
- Angles set for sun path on 21st March (equinox)
- Upstream and downstream sections instrumented
- Low and high blockage regions
Theoretical field located on the equator with angle accuracy $\pm 1^\circ$. 

0700 – eastern sun

1200 hours

1700 – western sun
Drag coefficient variation in field

- High upstream blockage
- Reduce mean windspeed
- Elevation angles reducing
- Greater fluctuation at row 1.5
- Reduction without tower
Lift coefficient variation in field

- Large decrease from first to second rows
- Flow partially recovers at centre
- Converging effects lead to reduction in lift
- Reduction in mean and peak without tower
Hourly coefficients

- 1200 hour coefficients increase downstream
- Relatively low blockage throughout the field
- Change in elevation angle
- Indicates time of day influences wind loading
Conclusion

• Upstream first row heliostats experience highest wind loads
  • Wind loading varies throughout a field
• Central tower effects downstream wind loading
• Field configuration changes wind loading within the field
  • Time of day determines amount of upstream blockage
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