The CSP Industry Perspective on Heliostat Optical Measurement: Learnings From Energy I-CORPS

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Interviews

| Total | 79 |
What is I-CORPS

DOE program designed to increase the economic impact of DOE-funded research.

Experiential program prepares scientists and engineers to extend their focus beyond the laboratory.

Provides valuable information to use in aligning resources to establish a viable commercialization pathway.

75 Interviews in 9 weeks
What is NIO

• NIO allows for the efficient optical assessment of a commercial-scale CSP solar field.
• Heliostats are scanned in seconds using Unmanned Aircraft Systems (UAS) imaging.
• The method produces detailed optical characterization data over the full mirror surface for every heliostat (slope, canting, and tracking error).
Agenda

1. Ecosystem and Value Proposition
2. Partnerships and Market Sizing
3. Interviews and Findings
4. Conclusions
PV

CSP Power Tower Ecosystem

Solar Field Performance Report

Full-service

Data

NIO Data Collection Service

Consultants

Software-as-a-Service

NIO hardware providers

UAS

NIO UAS requirements

NIO software package

Bidding, construction, commissioning phase

Developers

EPCs

Tech Suppliers

Plant operation phase

Owners

Managers

Power

Energy holdings

Investors

Differing opinions on the future of CSP

~ beyond ~

Interest in optical measurements beyond tracking (slope error measurements with drones)

Identify specific optical issues

Preventative maintenance

Redundant measurement systems

Differing opinions on the future of CSP

Updated: 6-8-3-19

PV
Value Proposition and Customers

Available as a system or service, NIO provides CSP owners, managers, and EPCs a full-field, high-precision optical performance measurement to ensure installed heliostats are within tolerance during commissioning and increase watts to the receiver up to 8% by isolating actionable losses in the solar field.

**Plant Owners**
- Identify and correct for losses impacting plant performance
- 80% have contracted outside measurement services

**EPCs**
- Verify installed heliostats meet manufacturer specifications
- 100% used in-house or third-party assessment at installation phase

**Plant Managers**
- Monitor field status for preventative maintenance
- Limited resources (less than 10% of O&M budget) to address costly in-field corrective maintenance
**Partnerships**

### UAS surveyors

**NIO needs:**
- Global reach
- Fast response
- Registered pilots

**UAS needs:**
- Additional service line and revenue from CSP sector

**NIO provides:**
- Specialized flight planning for autonomous data collection

**UAS provides:**
- Data collection service and delivers data to NIO

**Risks:**
- UAS company interest in CSP service
- Revenue volume insufficient to establish service line

### CSP consultants

**NIO needs:**
- Established experts to show better optics is more $.

**Consultants need:**
- A solution to prescribe for solar field performance concerns
- A solution to solar field underperformance. And $.

**NIO provides to consultants:**
- A prescription. And the only prescription, is more NIO.

**Consultants provide for NIO:**
- A prescription. And the only prescription, is more NIO.

**Risks:**
- NIO failing impacts consultant reputation
- Consultants recommending NIO when not suitable.
**Premium Power and Market Sizing**

- **What developers are saying…**
  - **Premium Power and Market Sizing**
  - **The power you’re producing is very valuable**

<table>
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<th>Value of recovered capacity</th>
<th>$0.00</th>
<th>$5,000,000.00</th>
<th>$10,000,000.00</th>
<th>$15,000,000.00</th>
<th>$20,000,000.00</th>
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<tr>
<td>Recovered power</td>
<td>$0.05</td>
<td>$0.10</td>
<td>$0.15</td>
<td>$0.20</td>
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**What we’ve heard:**

- Engineers and owners will pursue 1-2% improvements, internal R&D looks for even less.
- Control system responses to solar field issues have recovered up to 8% with aiming strategy.
- Plants have invested heavily to prepare for “peak power” seasons.
- Plants have invested in multi-year, million-dollar efforts to improve performance.

- **If the data is usable, the data is valuable.**

**Total Available Market O&M for CSP Tower**

- SAM: $10.2m
- SOM: $2.4m

**Power price-LCOE**

- Chile: $0.18/kWh (Statista)
- California: $0.20/kWh (eia.gov)

**Industry size may not support this yet.**
Interview Overview

CSP Plants
Owners/Operators and Managers
- Crescent Dunes
- Cerro Dominador
- Noor 3
- Cosin Solar
- BrightSource
- ACWA

Tech Suppliers
Heliostat and system designers
- Vast
- 24/7 Solar
- Heliogen
- 24/7 Solar
- Cener
- Tewer

Contractors
Services, consultants, and experts
- SolarDynamics
- Sunticc
- Planet A Energy
- Tietronix
- FTI

And others!
Plant Owners, Managers, and Leaders
Plants have invested heavily in optical performance

Control system upgrades over multi-million-dollar heliostat adjustment plan.

Calibration system upgrades to improve heliostat pointing

BCS calibrations have issues addressing far-field mirrors due to spillage intrusion on target and weak beam at long distance

Not all plants report issues calibrating, but can’t measure mirror shape

Fields are appropriately oversized for losses

To an extent, consistency is more important than meeting modeled output

Emphasized reliance on models

Plants have expressed interest in “knowing the state of the field”

Several calibration methods in development

But reportedly no issues with solar field

Plants have been reporting overproduction
Plant Decision Making

**Plant Managers**
- **Day to day operations**
- Operate with regular staff whenever possible
- Contract out when something breaks (ideally not often)
- Limited budget, staff, bandwidth for implementing new technologies/practices

**Plant Owners**
- Year to year, when things go wrong, or contracting
- Interest in annual field health checks (curiosity more than pain point)
- Varying levels of involvement
- More power may not mean more money – dictated by terms of PPA, incentives
Hypothesis: Optical field measurement is of value to plants and owners/managers will contract outside services to support this need.

Evidence for

- This has been done before
- 80% of the plants we spoke to contracted outside measurement services
- Done for fields not struggling with solar field calibration
- Need to identify sources of power loss
- 10-15% of losses due to aggregated solar field errors
- Difficulty deciding how to prioritize limited maintenance resources

Evidence against

- Not all plants have this need
- Plants may not be experiencing ANY issues with the solar field
- Consistent, reliable installation process and efficient calibration procedures
- Some heliostats not tunable in the field at all
- Money for this?
- Less that 10% of budget for O&M of the solar field
- Spoke to 5 plants, low number, but high percentage of CSP industry

Plants expressed a clear need, but how bad do they want it and how many of them are there?
Trends

- Slope error is a function of design: 100%
- Distant heliostats are difficult to calibrate: *60% (100% over 1km)
- Modeled power versus actual power matters: 100%
- Big heliostats are harder to calibrate: 100%
- Performance guarantees get you through commissioning: 100%

Biggest issue is the power block: almost all

Addressed in: almost all
Supported in: almost all

Metric is % of supporting responses out of # of times addressed.
Technology Suppliers
Interview Recap

Heliostat designers
- Cener
- Tewer
- Acciona
- SolarReserve
- Abengoa
- SBP
- Heliuss

System developers
- Vast
- Heliogen
- 24/7 Solar
- Magaldi
- eSolar
### Key Points

#### Heliosstat designers

- **3rd party assessment of optics is highly recommended**
- **Plants haven’t requested in-field validation from the designer**
- **All design parameters are developed internally (0.5-2 mrad common)**
- **Not every heliosstat is adjustable in the field**
- **A good heliosstat is in the design. In-field adjustments are costly. If they’re needed, you’re in trouble.**

#### System developers

- **Early on, wear all the hats. Owner, developer, EPC, tech supplier. Must go right the first time.**
- **The end user cares about power and cost. Needs to be in terms of power and cost.**
- **Beneficial to design heliosstats and receivers together**
Hypothesis: In-field measurements of heliostats in an operational environment after sale offers value to heliostat developers by providing performance guarantees and lower insurance premiums

Evidence for

- Heliostat optical accuracy of high value to developers
- Internal testing to meeting optical performance metrics (<2 mrad)
- Purchase of redundant measurement systems
- Performance Guarantees as selling point
- Demonstration of reliability in bidding process

Evidence against

- Plants are not asking for this data from developers
- Cost is a bigger factor in the bidding process
- Rarely follow-up from plants on in-field performance
- Heliostat developers do not currently see this as an option
- Developers had not considered possibility of lifetime measurements

Insufficient evidence to support this as a viable business model in the current industry, perhaps in the future...
Contractors and Consultants
Interview Recap

Contractors/Consultants

- FTI
- Tietronix
- Planet A Energy
- Sunntics
- Aelius

Service providers

- CSP Services
- Tewer
- UAS companies
Key Points

Consultants/Contractors

- Solar field losses are not explicitly characterized, strictly expected vs received power.
- But, models often include itemized loss-budgets based on specs from heliostat designer.
- Strong models are crucial for optimization and performance monitoring.
- Plants can be overwhelmed with technical issues, must help identify which ones matter.

Service providers

- Very little business for CSP service providers is in the tower sector (5-10%).
- Field measurement campaigns (as a service) are ~$20-50k, not big moneymakers.
- Big-ticket items sold are automatic measurement systems.
- Plants often don’t know what they need when requesting services.

Performance guarantees are used for commissioning, must hit % of design power.
Disputes occur when actual watts don’t meet design watts – whose component is at fault?
Contracts are not written with enough technical detail/requirements for optical performance.
Main Takeaways for NIO

Assumptions going in

Commercial plants are struggling with optical measurement of the solar field

Measurement of the solar field is a priority at commercial plants

The reality

Some do, not all, depends on installation, calibration, and field/mirror size

BUT, fields that do not struggle with optical measurement are still interested in third-party validation

Generally, no, tank or power block issues take priority

Plant managers have limited staff and budget

New avenues to pursue

Cheaper alternative to an “over-sized” field

High value at the installation and commissioning stage

Long term operational data for tech suppliers for performance guarantee and reduction of insurance premiums

Uses in PV?
What developers are saying…

**Takeaways from Energy I-CORPS**

**Ask effective questions**
- Before developing something new, is it needed?
- If it’s needed, can the industry afford it?
- How will industry interact with it?
- How ready is the industry for adoption?

**Improve communication**
- Use language the resonates with the end user
- 1-on-1 interviews yield genuine conceptions

**Replace assumptions with data**
- Are they meeting design power? How close is it?
- Is this acceptable?
- How much is it costing them?
- Is there an incentive to overproduce?

Can’t assume something will sell just because it makes an improvement. Everything has a cost!
More from HelioCon

- Past seminar presentations available on the HelioCon seminar webpage: [https://heliocon.org/resources/heliocon_esev.html](https://heliocon.org/resources/heliocon_esev.html)
- More resources can be found on the HelioCon resources webpage: [https://heliocon.org/resources/resources-1.html](https://heliocon.org/resources/resources-1.html)
- Subscribe to the seminar series or get in touch: [heliostat.consortium@nrel.gov](mailto:heliostat.consortium@nrel.gov)

Next Seminar September 27th!

HelioCon Seminar Series: Challenges and Solutions in Heliostat Optical Metrology
Speaker: Dr. Randy Brost, SNL
When: 1-2 pm MDT Wednesday September 27th
Zoom: [https://nrel.zoomgov.com/j/1613394621](https://nrel.zoomgov.com/j/1613394621)