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Technology*



Interviews	
Total	79



What is I-CORPS



ENERGY I-CORPS

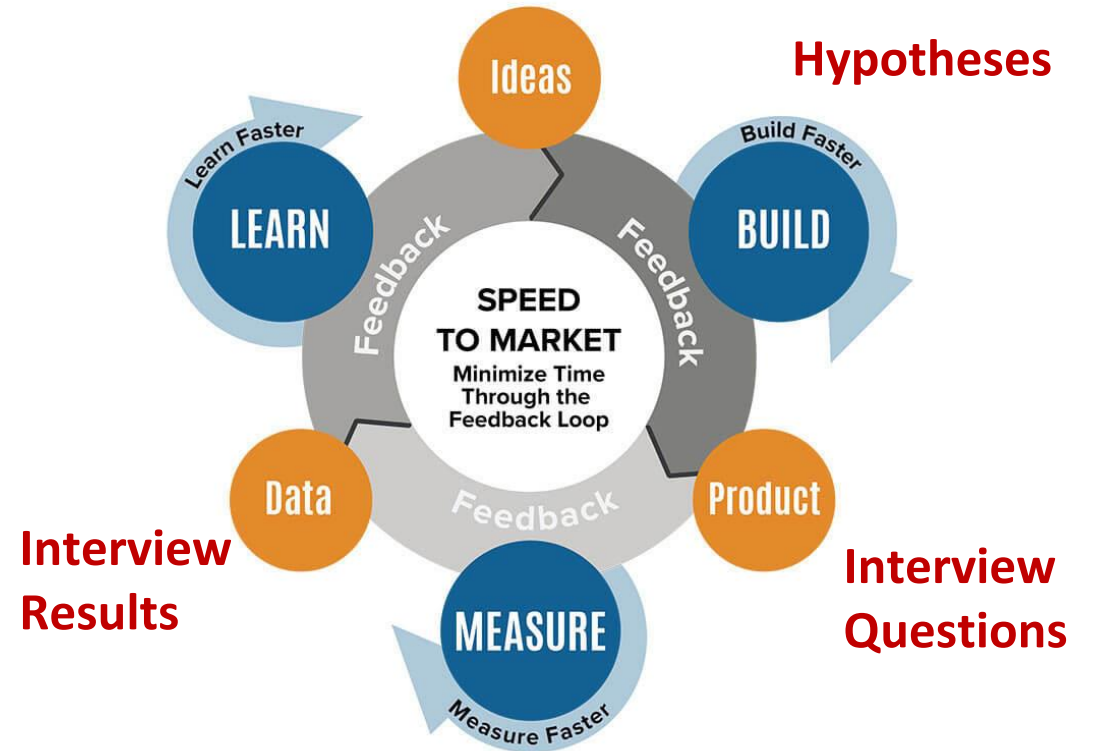
U.S. DEPARTMENT OF
ENERGY | OFFICE OF
Technology Transitions

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.

BUILD ► MEASURE ► LEARN

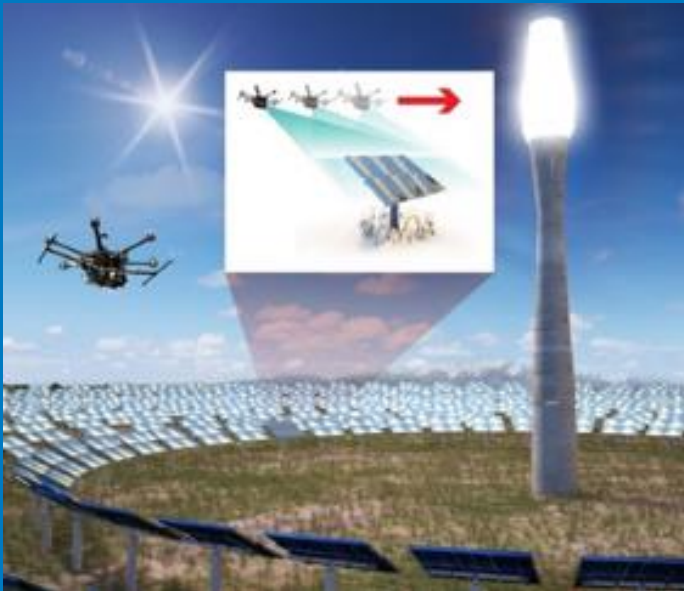


75 Interviews in 9 weeks

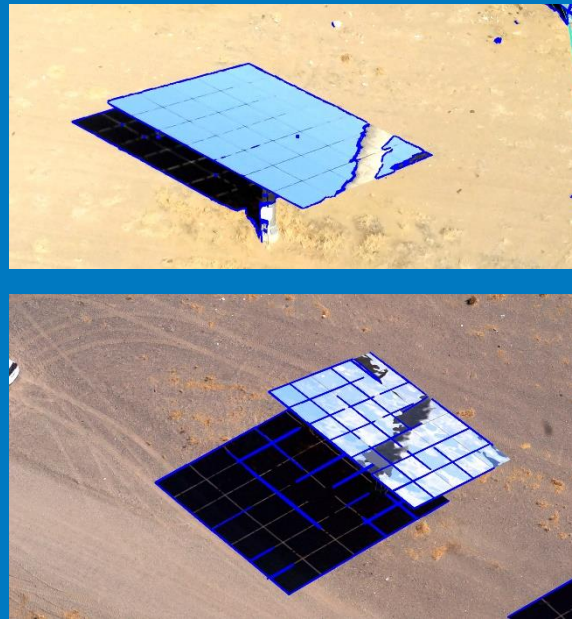
What is NIO

- 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).

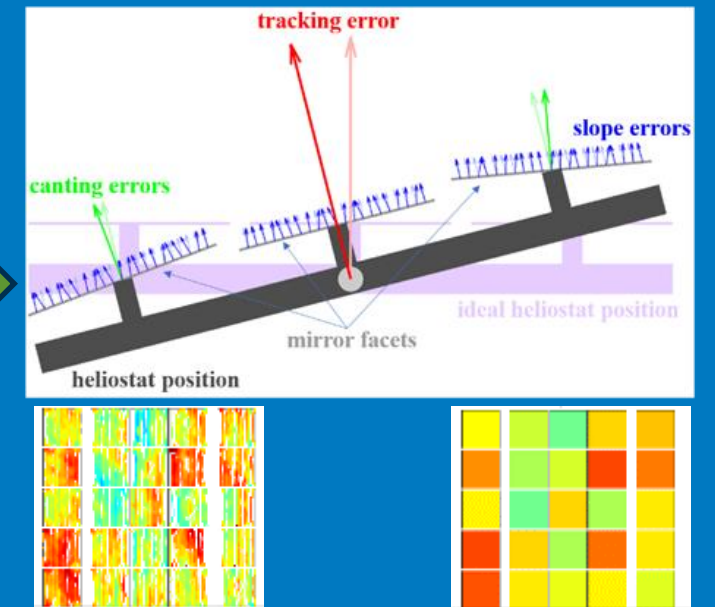
UAS data collection



Computer vision and ML image processing



Optical error characterization



Agenda

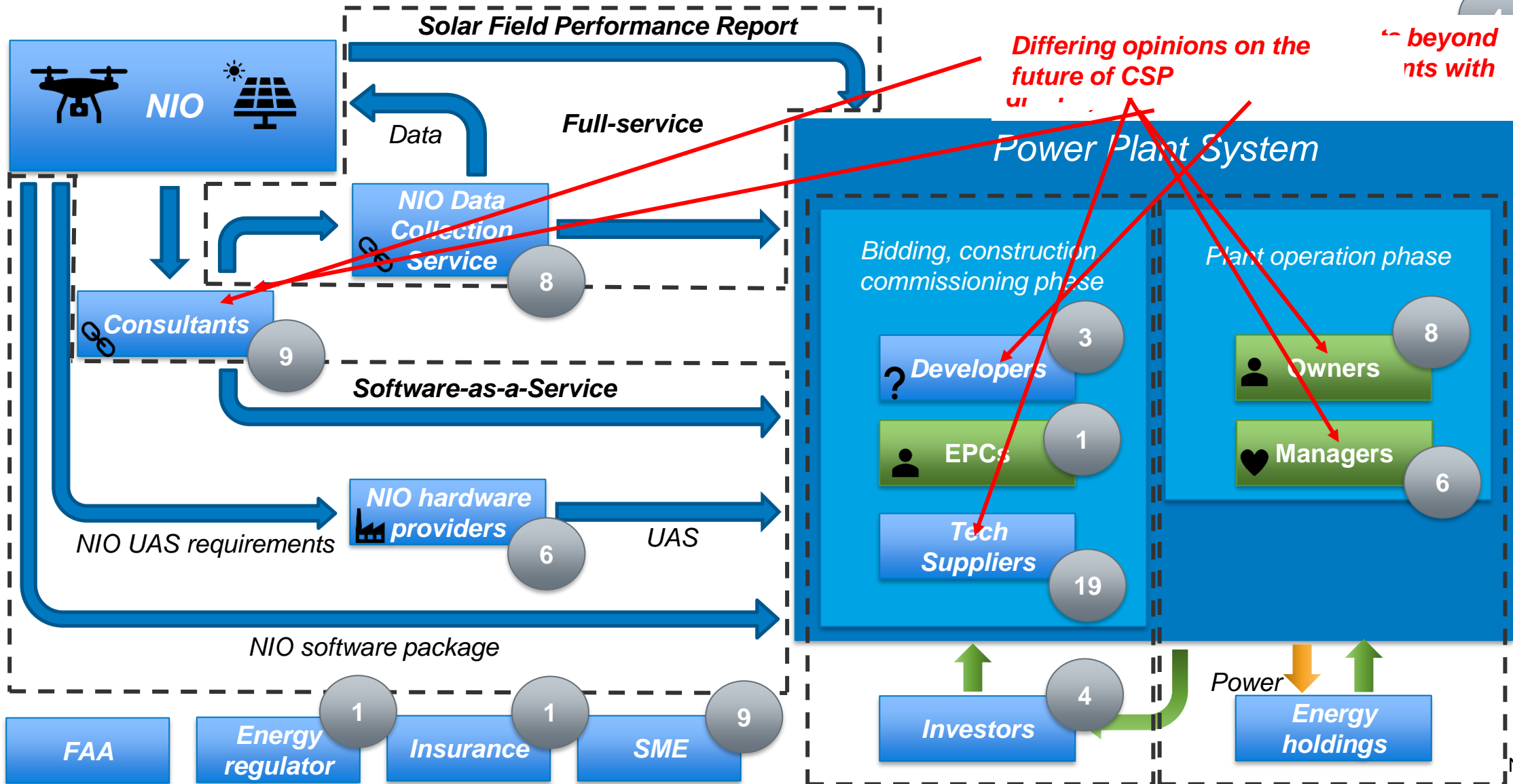
1 Ecosystem and Value Proposition

2 Partnerships and Market Sizing

3 Interviews and Findings


4 Conclusions

CSP Power Tower Ecosystem




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

NIO provides to consultants:

A solution to solar field underperformance. And \$.

Consultants provide for NIO:

A prescription. And the only prescription, is more NIO.

Risks:

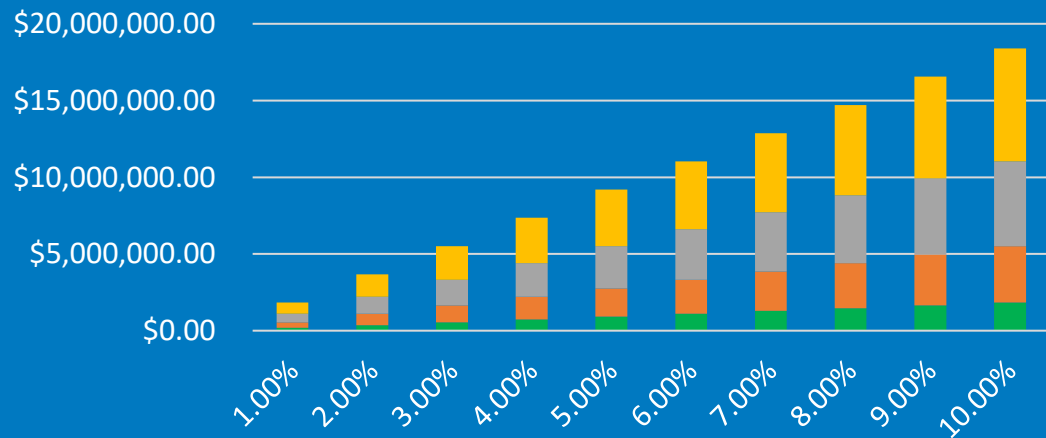
NIO failing impacts consultant reputation

Consultants recommending NIO when not suitable.

Premium Power and Market Sizing

“The power you’re producing is very valuable”

Value of recovered capacity



Avg Price/kWh USD
 Chile: \$0.18 kWh (Statista)
 California: \$0.20/kWh (eia.gov)

Recovered power
 \$0.05 \$0.10 \$0.15 \$0.20
 Power price-LCOE

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.*

Industry size may not support this yet

Total Available Market
O&M for CSP Tower

\$170 million

SAM

\$10.2m

SOM

\$2.4m

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*



Identified Uses of NIO

Solar Field Diagnostics

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

Solar Field Monitoring

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"

Internal R&D

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

NIO Use-Case

Plant decision makers as a customer segment

Hypothesis:

Only

Tentatively Proven

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

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 than 10% of budget for O&M of the solar field

Spoke to 5 plants, low number, but high percentage of CSP industry

Trends

Biggest issue is the power block

Addressed in: almost all
Supported in: almost all

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%

Tech suppliers

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

Heliostat 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 heliostat is adjustable in the field

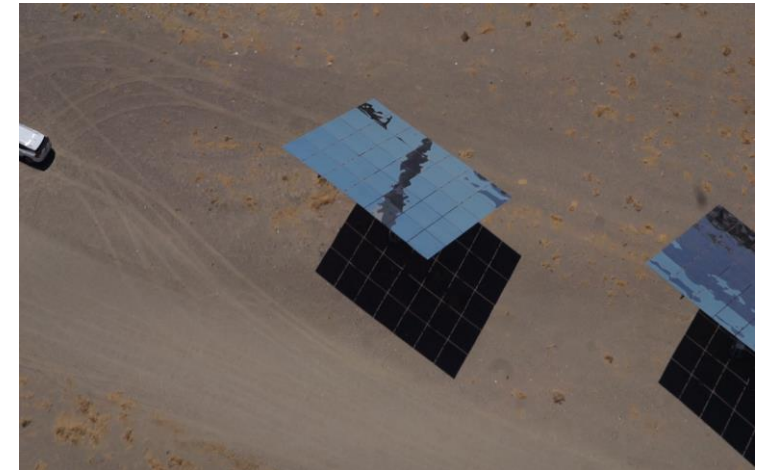
A good heliostat is in the design. In-field adjustments are costly. If they're needed, you're in trouble.

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 heliostats and receivers together



NIO Use-Case

HelioStat developers as a customer segment

Hypothesis:

In-field measurement of helioStat performance by providing performance guarantees and lower insurance premiums

Evidence for

HelioStat optical accuracy of high value to developers

Performance Guarantees as selling point

Internal testing to meeting optical performance metrics (<2 mrad)

Demonstration of reliability in bidding process

Purchase of redundant measurement systems

“Performance guarantees” and “insurance premiums” language that came from developers

Evidence against

Plants are not asking for this data from developers

HelioStat developers do not currently see this as an option

Cost is a bigger factor in the bidding process

Developers had not considered possibility of lifetime measurements

Rarely follow-up from plants on in-field performance

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

Sunnitics

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

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

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

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?

Takeaways from Energy I-CORPS

Ask effective questions

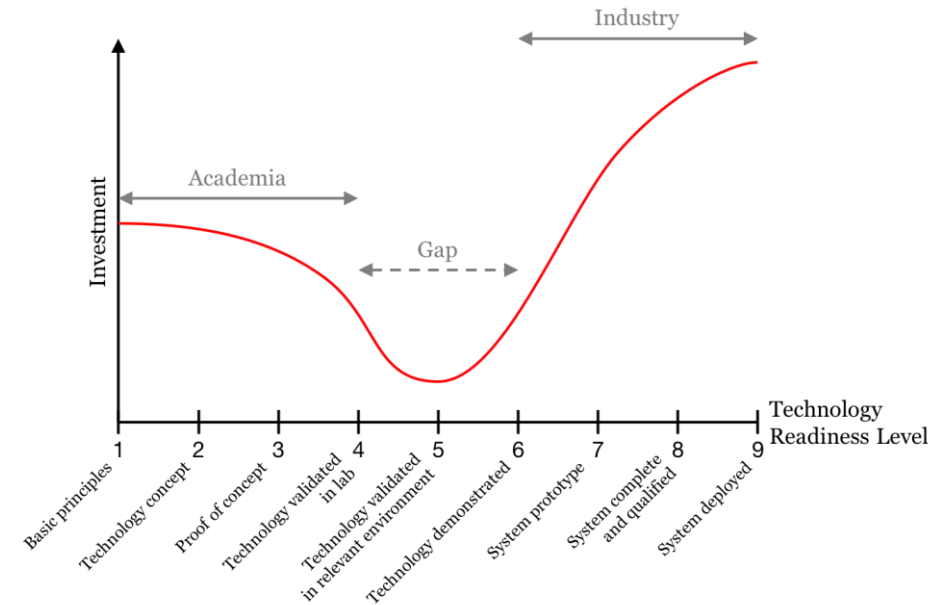
- Before developing something new, is it needed?
- If it's needed, can the industry afford it?
- How will industry interact with it?
- How ready is the industry for adoption?

Improve communication

- Use language that resonates with the end user
- 1-on-1 interviews yield genuine conceptions
- Make. Better. Slides.

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!

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Thank You

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- Past seminar presentations available on the HelioCon seminar webpage:
https://helioccon.org/resources/helioccon_esev.html
- More resources can be found on the HelioCon resources webpage:
<https://helioccon.org/resources/resources-1.html>
- Subscribe to the seminar series or get in touch:
heliocon.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>

