U.S. Department of Energy
HelioCon
Heliostat Consortium for Concentrating Solar-Thermal Power

Gap Analysis of Heliostat Field Deployment Processes

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conceptual design • components • integration • mass production • heliostat field

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Field Deployment Overview

- Field deployment captures all activities required to establish a functioning solar field

Site Selection

End of Life

Field Layout

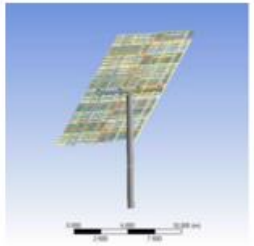
O&M

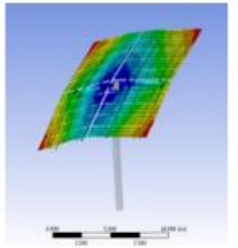
Field Deployment

Supply Chain

Assembly/ Construction

Quality Control





Site Preparation

Capitalization

Stakeholder interviews and workshops

Utility concerns:

- "Fleet of old generation plants are going down. 1000s of MW are going off and we need to replace with new capacity. We just need the technology to work."
  - Reliability and power production case needs to overwhelm existing skepticism. Too many plants have underperformed.
- "PV+battery is much more competitive than thermal storage. The market has evolved."
- "SCE solicited 4GW of storage over the next 4 years – all batteries. It's tested, modular, proven"
- "Speed is definitely a big deal. Battery supply is tough to get due to a manufacturing bottleneck, so the whole project cycle is 18 months for a battery project. "
- "We do not plan on pursuing another CSP plant at this time. It's not 2010 {incentives, market}
- "Medium term 8 hour storage is interesting but we only need just enough storage during the peak load from 5-9pm."
- "We still need synchronous loading"

Stakeholder interviews and workshops

Investor concerns:

- "How much money? How much risk? Schedule to ROI"
- "$1 Billion is high risk, by the time you get all the institutions lined up the market moves on."
- "Projects in the $200-300 million range are the sweet spot"
  - "Go small! Get deployable with small modules that can meet any spec."
- "Years of zero revenue because technical solutions were difficult to find. Modular layouts will prevent these single points of failure."
- "Is your EPC properly capitalized to stay long term and will they commit no matter what?"

Stakeholder interviews and workshops

Developers:

- "There is no consensus on optimal size. We used to think the correct heliostat was the largest thing you could fit on a pile
  - "Think about the $10 water-tight connector"
- "Don't get too caught up in the cents {LCOE}! Fields that are more deployable may be more attractive. LCOE will come down with economies of scale"
- It's hard not to get locked into a design too early. People develop trusting relationships with suppliers during development which can make it hard to make needed changes if they sour those relationships.

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HelioCon Field Deployment

- Objective: reduce heliostat field deployment costs
  - Mature heliostat technology and develop cost saving deployment technologies
    - Site x Heliostat specific
    - Time dependent
    - Cost models for deployment lack validation by EPCs

- Increase Learning Rates and Economies of Scale
  - Permitting challenges
  - Lack of market stability
  - $1B a try

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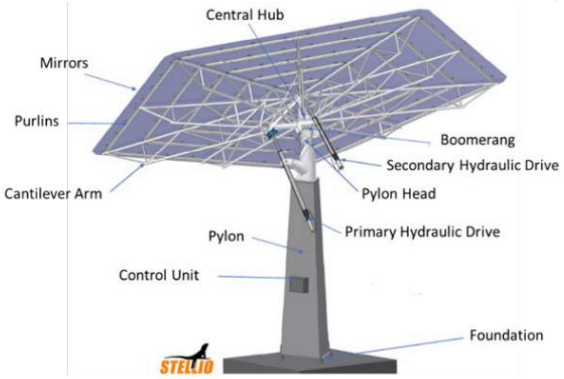
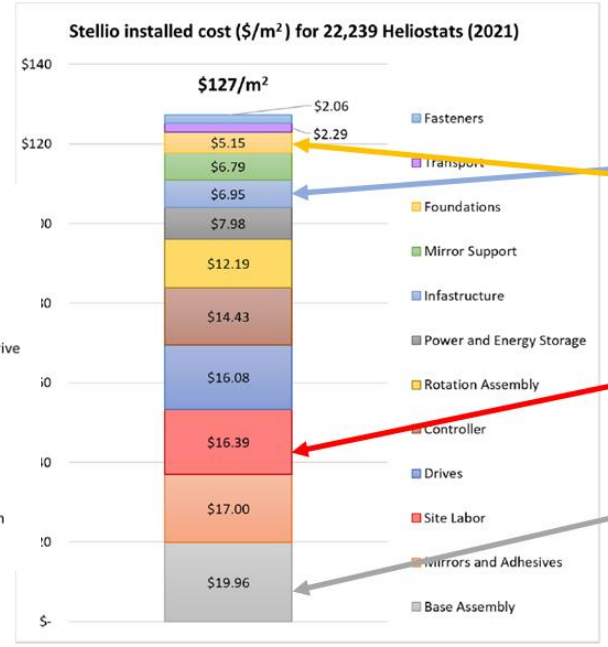
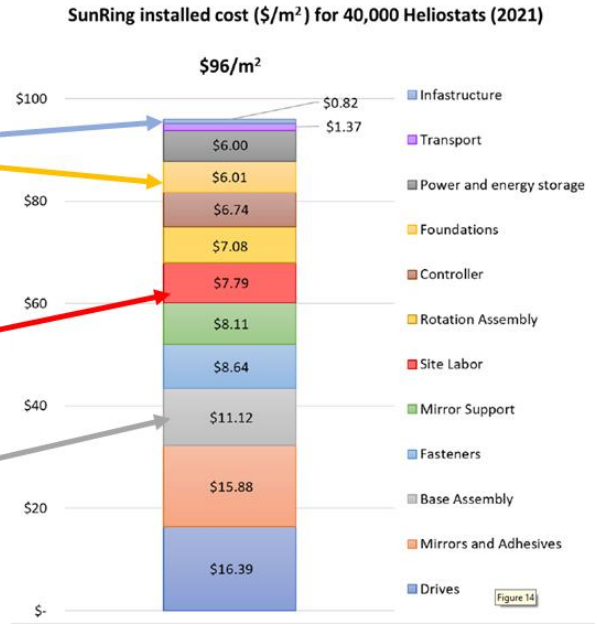
Gap: Deployment costs are not well known

- Gap: Cost models for deployment lack validation by EPCs
  - Site x Heliostat specific, Date dependent, Cost models for deployment lack validation by EPCs
- Kurup et al. present a cost analysis of the Stellio and SunRing heliostat designs using DFMA Software
  - This study does not include optical properties. LCOE studies for Roadmap have shown that heliostat costs savings must be substantial if they reduce optical performance even slightly
- Top down (1/3 total cost for field) indicate deployment may be ~$180/m2 not including O&M. (Gap is 3x the SETO goal!)

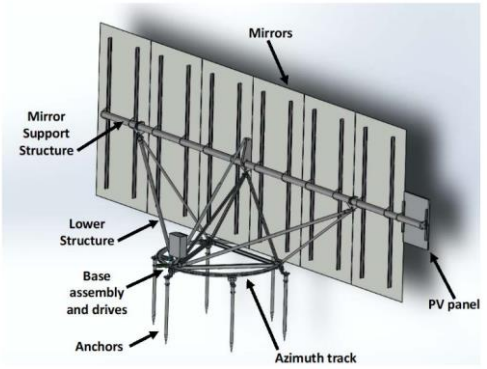
Deployment-related costs
$59.87/m^2







Deployment-related costs
$27.11/m^2



Kurup, P., Akar, S., Glynn, S., Augustine, C., & Davenport, P. (2022). *Cost Update: Commercial and Advanced Heliostat Collectors*. Retrieved from United States:

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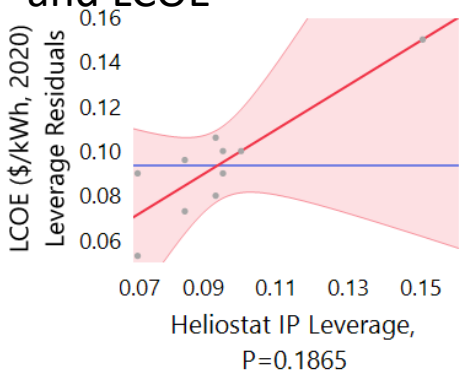
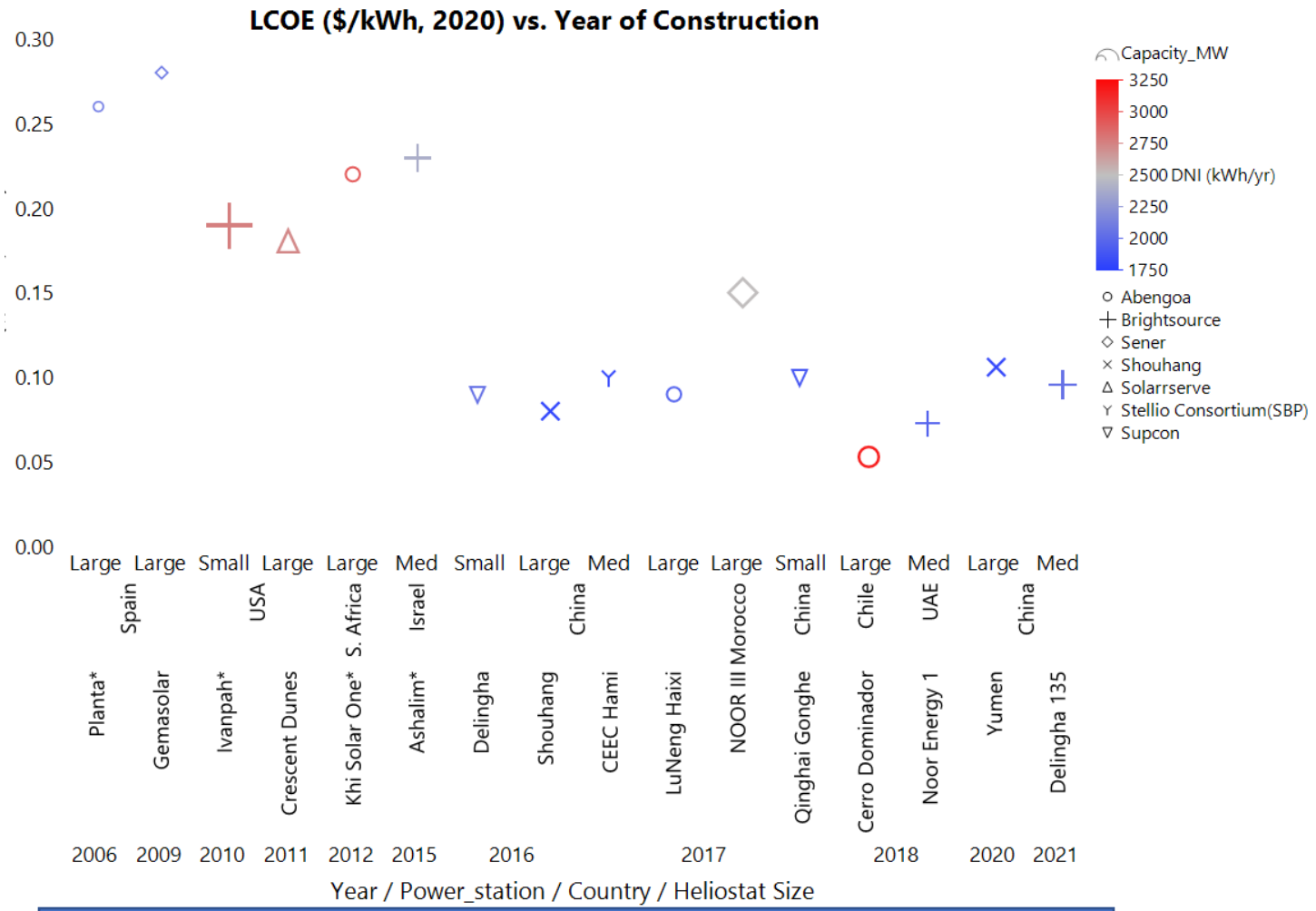
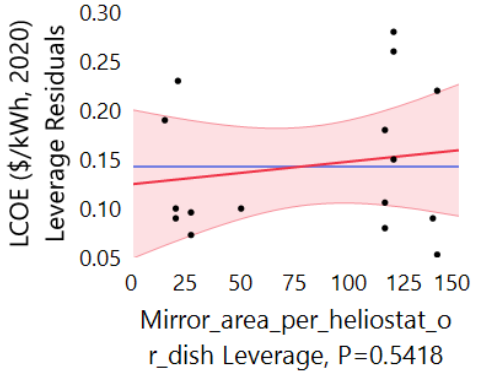
Published data overview

- Unlikely correlation between Heliostat IP and LCOE

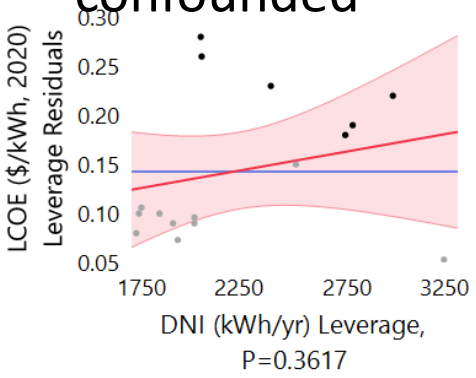




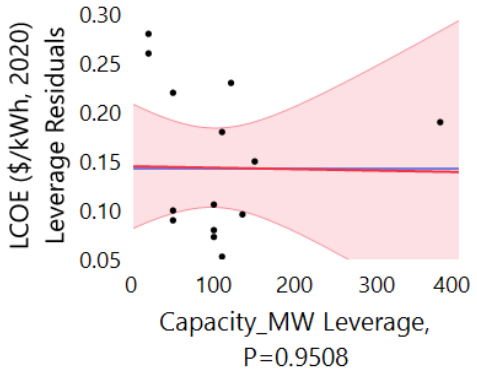
- Unlikely correlation between heliostat size and LCOE



- DNI correlation to LCOE is highly confounded



- Unlikely correlation between plant capacity and LCOE



Accessible data may not capture the driving factors of field deployment costs (or LCOE)

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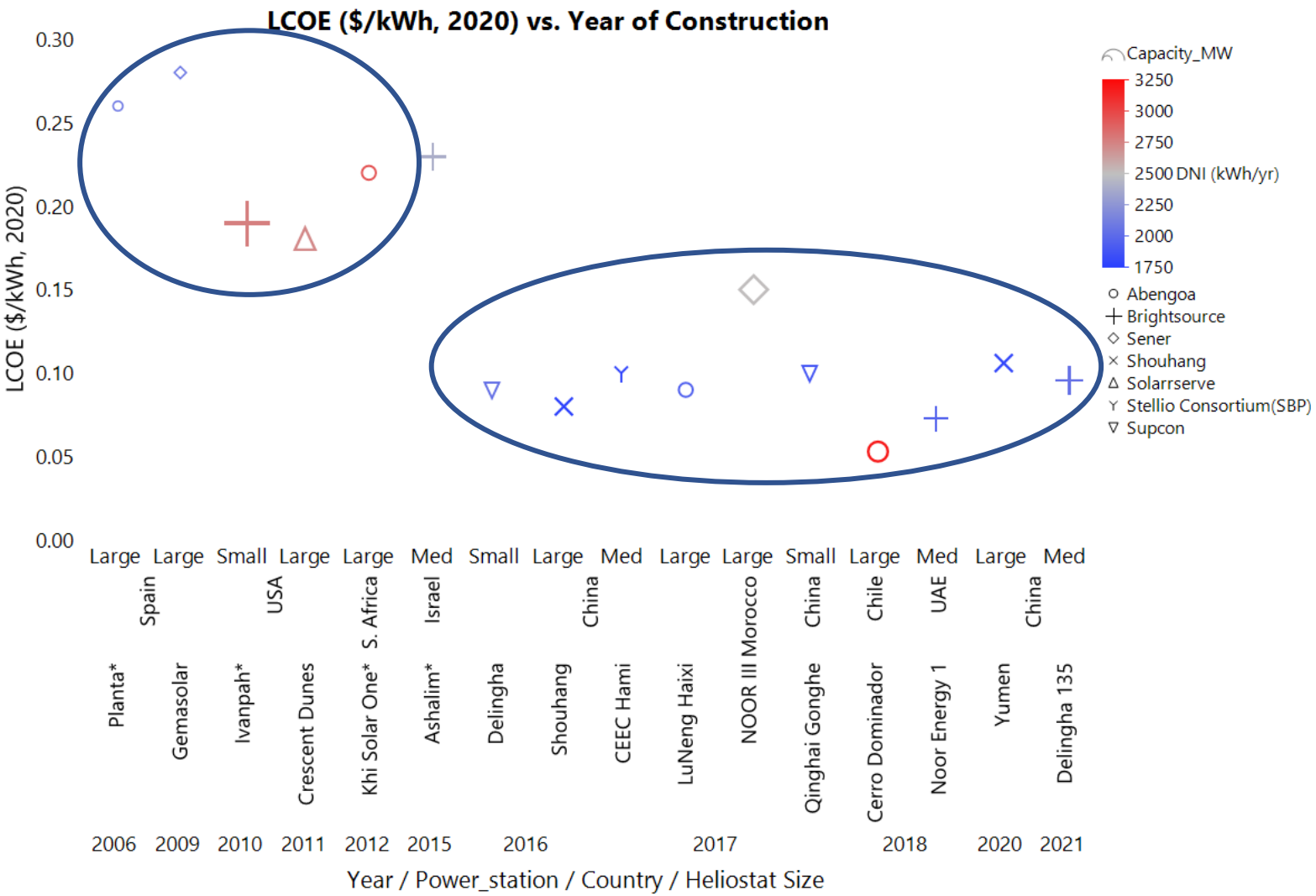
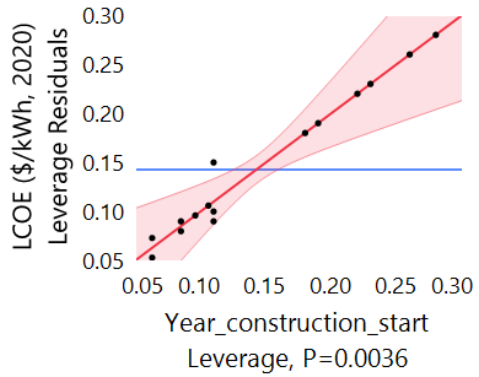
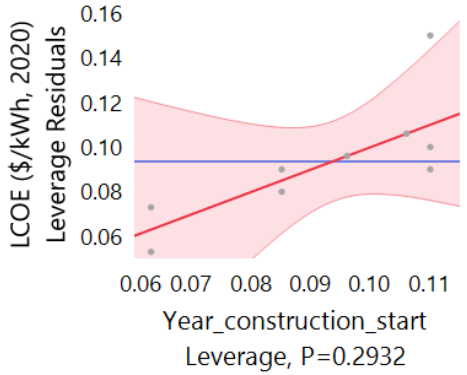
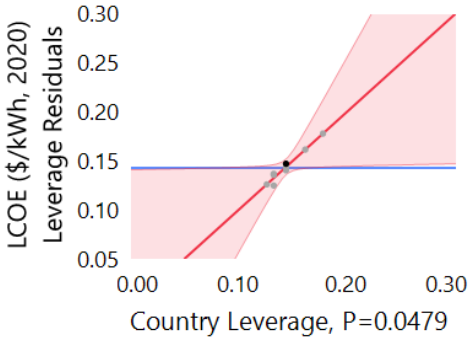




- Likely correlation between year and LCOE



- If we separate the first wave plants, the correlation with year goes away



- Mild correlation between Country and LCOE, controlling for year and DNI

Data acquired from:
Lilliestam, J., Thonig, R., Zang, C., & Alina, G. (2021). *CSP.guru (Version 2021-07-01)*. http://doi.org/10.5281/zenodo.5094290. Retrieved from: https://solarpaces.nrel.gov/

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Economies of scale and learning rates

- Johan Lilliestam et al.
  - Average PV learning rate is 20% since 1990
  - Trough CSP shows learning rates exceeding 25%
  - CSP with heliostats never seems to get enough deployments to meet the following conditions:
    - long periods of stable production and policy support
    - learning curves are more pronounced within a single company/organization
    - cost pressure from competition was present
- Solution:

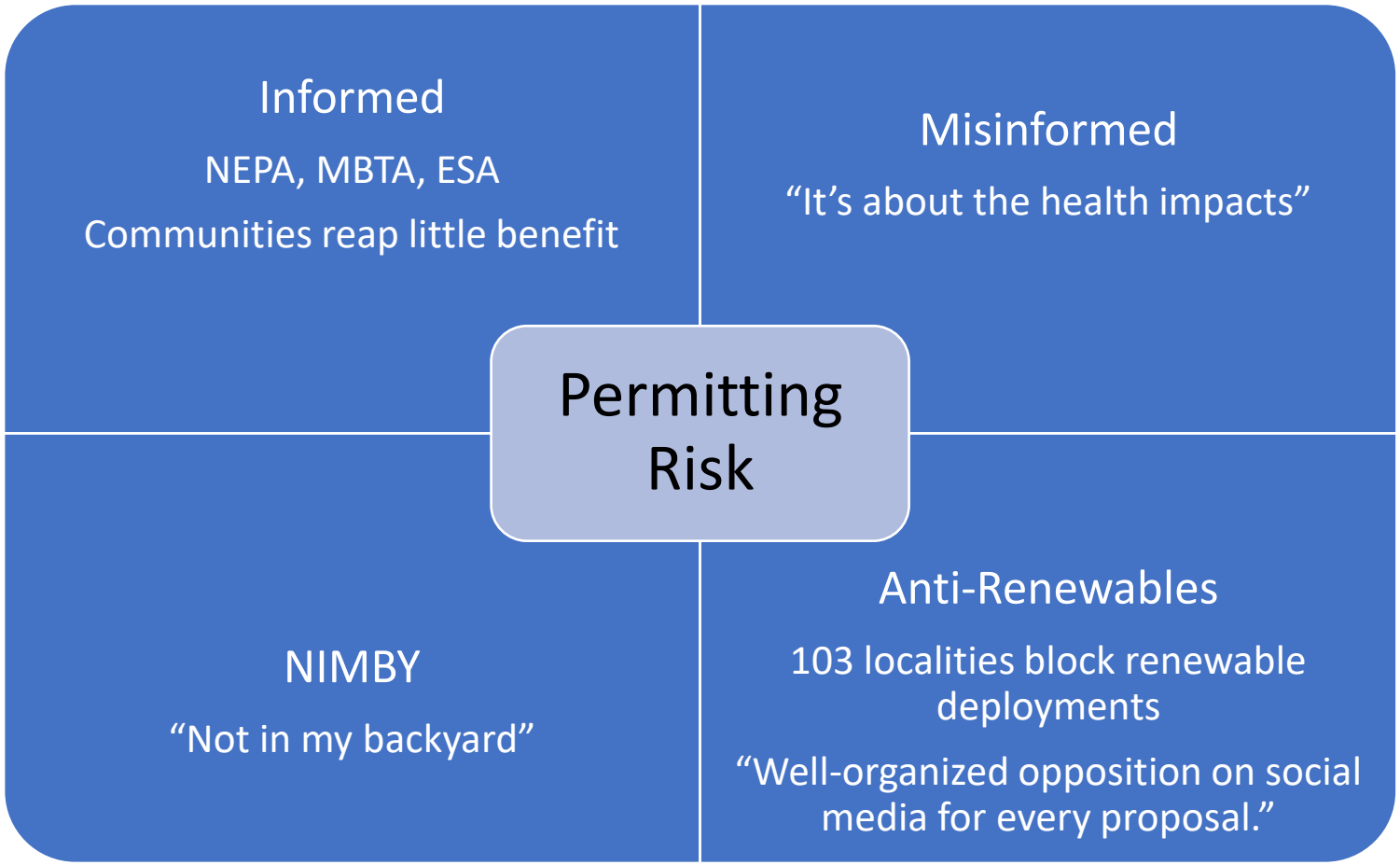
conceptual design • components • integration • mass production • heliostat field

Gap: System models underperform

- Solution: revise models
  - Known uncertainties (Planned HelioCon scope):
    - O&M and Field Deployment (EPC/Developer Study)
    - Wind related losses
    - Soiling
  - Unknown uncertainties (Findings in EPC/Developer data analysis)
    - Contributing Factors
      - Location dependent factors
      - Nation-based factors

Permitting Risk

- “1.7 GW of proposed solar cancelled in permitting phase in 2021” - Reuters
- “Site acquisition is a top threat to growth”- LevelTenEnergy poll



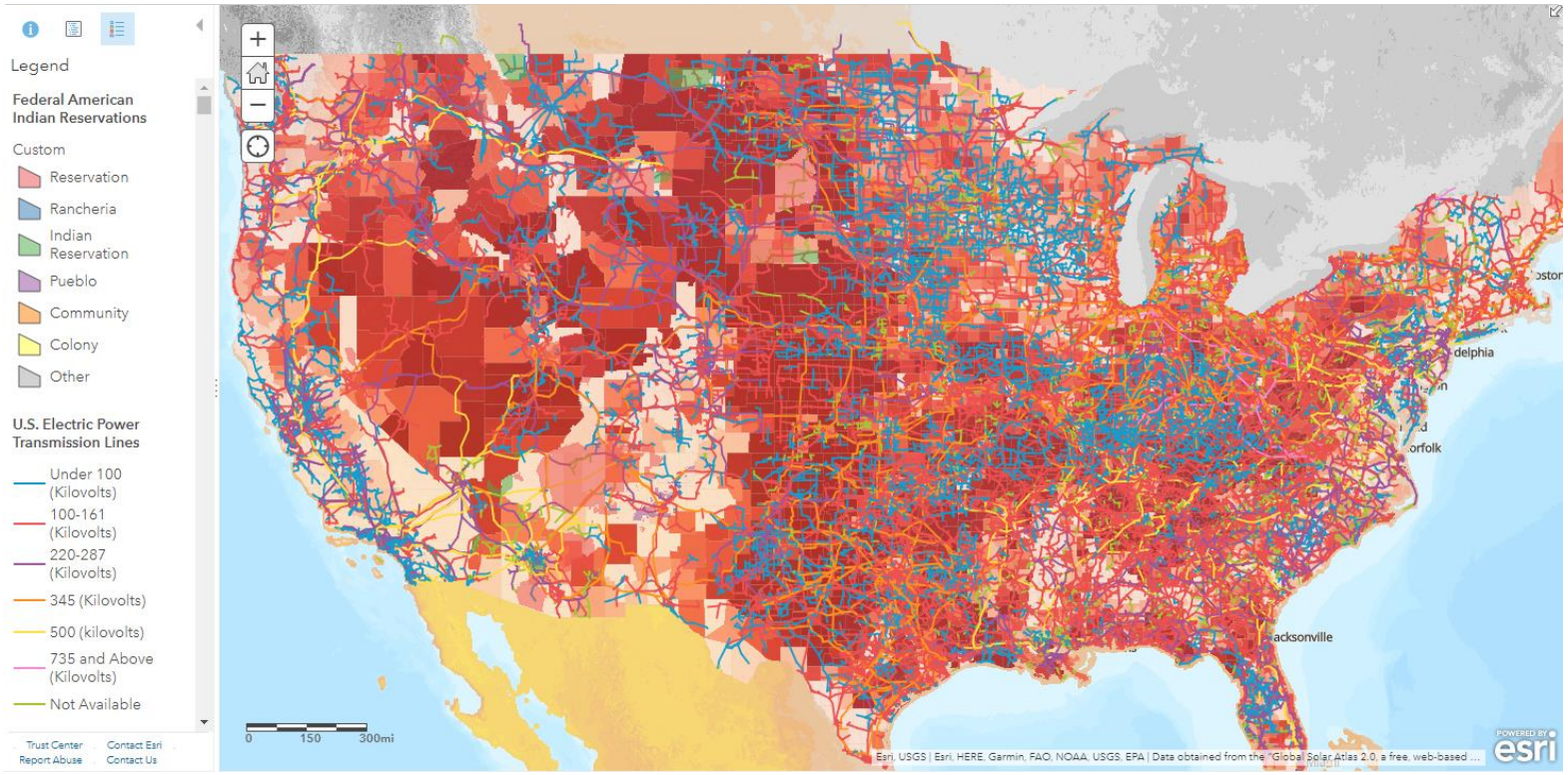
Permitting risk reduction

- Informed:
  - Avian and terrestrial wildlife detection, avoidance, and deterrence technologies
  - Undisturbed terrain
  - Waterless and low water washing technologies
- Misinformed
  - PR campaigns
  - Early community engagement and education
- NIMBY
  - Socioeconomic analysis of community impacts/benefits
  - Aesthetic layouts and siting to avoid view of receiver
  - Modular systems with smaller footprints
- Anti-renewable groups
  - Correlation study to determine the likelihood of opposition based on political and socioeconomic data

Solution: Study socio-politically informed siting

Siting Criteria

- Solar Resource
- Transmission Lines
- Consultation with Indigenous/Rural communities near proposed sites
  - Several Pueblos, Tribes and the Navajo Nation have recently deployed commercial scale solar energy in the last year.[1,2]
  - Indigenous-led solutions may inform the way CSP could be deployed for these communities.
- Politics
  - Energy commissioners have sided with opposition groups who do not want renewable deployments in “back yard”[3]
  - Environmental groups have also opposed CSP deployments due to concerns for wildlife and water use



1. https://www.energy.gov/articles/doe-awards-9-million-tribal-communities-enhance-energy-security-and-resilience

2. https://www.energy.gov/sites/prod/files/2019/01/f58/2.1-Picuris.pdf

3. https://www.reuters.com/world/us/us-solar-expansion-stalled-by-rural-land-use-protests-2022-04-07/

Lack of Market Stability

- Address barriers to market diversification
  - IPH applications may have much lower cost of entry and more control over developments on site.
  - Develop software models that address key questions for interested IPH exploration
    - Where do we put the heliostats and how big would the field be?
    - Where does the receiver or tower go?
    - Are heliostats the right solution in our site?
  - Risk reduction for utilities
    - Reliable
    - Dispatchable
    - Resilience

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