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

Heliostat Consortium: Field Deployment

Status Quo of Heliostat Field Deployment Processes

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

Overview

- Preparation and RFP
- Site Selection
- Field Layout
- Supply Chain
- Assembly
- Site Preparation, Construction and Installation
- Calibration
- Operations and Maintenance

Preparation and RFP

- CSP Plant developer responds to RFP issued by power company
  - Deployment proposal package typically due in 2-3 months
    - Risk assessment
    - ✓ Reliability basis
    - ✓ Guarantee of Performance
    - ✓ Solar field system design
    - Power purchase agreement
    - Secured capitalization and construction plan
      - ✓ Coalition of investors, developers and EPCs
      - Is EPC materially invested and properly capitalized to absorb losses
    - Legal egress to interconnections
    - ❖ Resolution proposal for all anticipated or existing land use issues
  - Post-bid hurdles
    - ✓ Environmental
    - ✓ Cultural (rural and tribal)
    - Opposition groups
    - Political support
    - ❖ Public relations campaign
    - ✓ Developing technology with lack of standards, shifting specifications and contract acceptance criteria

✓ = HelioCon

❖ = DOE outside of HelioCon

Renewable portfolio standards

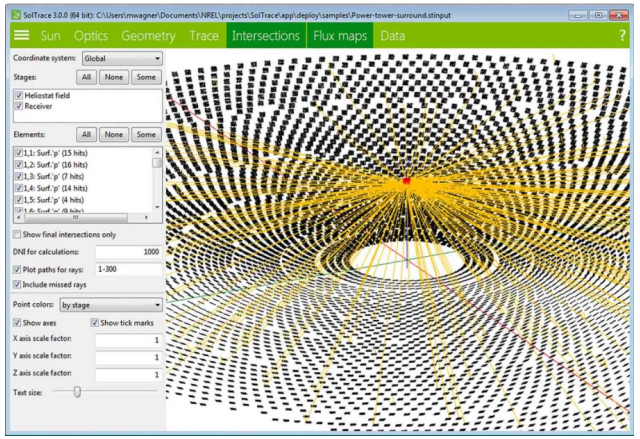
- Competition in RFP limited to renewable energy sources
- Deployment times
  - Wind and PV assume deployment in 6 months (18 months with batteries)
  - ✓CSP assumes 24-36 months but efforts to reduce to 18 months are underway
  - Financing terms and ITC/PTCs may change if project cannot deploy within a political cycle
    - Rice Solar – ITC drops from 30%-10%
    - Redstone awarded in 2015, deployed in 2021
  - Retirement of fossil plants must have simultaneous replacement by renewables

Site Selection

- Ideal
  - DNI, visibility, large flat land area, low winds, convenient grid tie, nearby labor force and water supply
- Scouting prospective sites
  - ✓Developer does not always get to choose the location and must meet the RFP requirements regardless of DNI and land conditions etc.
  - Sites can be selected for political reasons such as bringing jobs to a district or civil infrastructure developments
  - RFP will specify life of project – disincentive for higher quality components
  - Irradiance maps consider clouds averaged over decades but may not consider shading from new airline paths or more frequent forest fires
  - Geotechnical data may not be available within RFP window
    - ✓Heliostat size vs geological soil profiles

Field Layout

- Receiver is selected which constrains the field
- Ray tracing software optimizes positions
  - More advanced systems can accommodate elevation and avoid collisions for denser packing
  - Raw unleveled fields are common
  - Receiver view of reflectors is nearly solid
- Installation plans
  - ✓Large heliostats use pylons or piles to hold foundations
  - Small heliostats can use ballasting
  - Land changes over time so some fixtures are still necessary
    - Grouping heliostats with frame has been tried
  - Inner field wind blocking effects
    - Mass reductions in components may not offset mass production savings
  - GPS can locate heliostats within 5 cm
  - Cabling and trenching is competitive with Wi-Fi and solar panels (Ashalim, DEWA, Redstone)



Supply Chain

- Supply chain for entire project is often required in the RFP
  - Difficult to change because system-wide re-analysis can be required
  - Relationships with suppliers are difficult to change
  - Manufacturing relationships
- Supply-chain vulnerability
  - Deployments are several years or decades apart undermining investments in cost-cutting technologies
  - Glass and backing fabrication techniques are guarded by ~3 facet companies
- Materials and components
  - Mapping humidity and oxidation rates to the backing material improved since 2012
  - Minimization of backing materials has reduced costs (region humidity specific)
  - Pedestal alloy material minimization (region humidity specific)

Assembly

- Size considerations
  - No standard
  - Per-heliostat component costs favor more facets
  - Small heliostats have lower wind resistance and compatible with factory assembly
  - Large heliostats have large pylons or deep piles vs. ballasted/small pile
- Quality considerations
  - Heliostats should consider cost of life of plant not just arrival but not standard
  - Components often arrive several years before assembly making issues undiscoverable until very late
- Procurement
  - Process is onerous and can cause delays or cancellations (bids were reviewed for 2.5 years in one plant)
  - Optimization of size to fit standard shipping containers may reduce costs
- Assembly
  - Labor force may be low in plant areas favoring more assembly off-site
  - Investment in assembly shops affected by delays between projects favoring off-site

Site Preparation, Construction and Installation

- Automation is being developed to reduce construction labor costs
  - Heliogen developing fully autonomous heliostat transport and locating systems
  - Field improvements and leveling may be more important for robotic installation systems
  - Impacts of labor swell on local communities can form a boom-bust cycle

- Government works investment
  - Job creation motivates support for these types of projects
  - BIL provides basic 30% ITC but job considerations may reduce costs
    - +10% low-median income of tribal areas
    - +10% re-equipping, expansion, or establishment of manufacturing facility (on-site assembly?)
    - +10% using products produced in United States
    - +10% deploying in “energy communities” (closed down coal plants)
    - +20% low-income economic benefit project
  - Wage requirements and union worker requirements may be a factor in federally funded projects

Site Preparation, Construction and Installation

- Field preparations
  - Trenching and leveling is large cost and may increase erosion affecting wash truck egress
    - Brightsource minimizes field alterations to minimize erosion, environmental impacts
      - Plants are trimmed but not eliminated
    - Brightsource has deployed wireless fields with individual solar panels to minimize trenching costs
    - Lightning is considered a risk for wired fields

Calibration

- Assembly room calibration
  - Detailed methods using screen patterns
- Field calibration
  - Pointing error determined with BCS photogrammetry (difficult for distant heliostats)
  - UAV-based systems are being developed (UFACET, NEO)
  - Tower mounted camera and flux sensor techniques used to recalibrate periodically
  - Projectors and light sources
- Software
  - Ray-tracing
  - Image processing
  - Video processing
- SolarPACES Topic 3 task force will present details on field calibration techniques

Operations and Maintenance

- Heliostats are typically very reliable (>90% availability)
- Calibration and performance monitoring cycle through field
- Cleaning
  - Larger heliostats typically use trucks (COSIN has deployed autonomous trucks)
  - Smaller heliostats can use crews
- Sustained labor
  - <10 field maintenance personnel
  - ≤ 5 operators
  - ≤ 2 facet cleaners
    - Ashalim crew can wash 50,000 heliostats by hand 20-25 times a year using 3 liter water per heliostat
- Operations
  - Aim-point strategies are being replaced with more sophisticated strategies to constantly focus and defocus to maintain optimal HTF temperature (Brightsource)
  - Avoidance techniques for birds and wildlife have improved substantially (circular standby)
  - Operations have achieved full autonomy and remote monitoring
  - Intelligent heliostat routing has been demonstrated where heliostats constantly know path for emergency scatter without hitting tower or colliding with other heliostats (Brightsource)
  - Intelligent weather and cloud detection techniques protect receivers

Summary

- Heliostat field technology has made great strides since the early fields circa 2013
  - Autonomous field operations
  - Autonomous washing trucks
  - Full field calibration cycles
  - UAV-based evaluation techniques
  - Remote monitoring
  - Wireless control
  - PV+battery deployed on each heliostat
- Significant levels of support in US
  - BIL/IRA tax incentives
  - DOE funding and loan guarantee program