Solar Thermal Site Screening

Summary of forthcoming "Guideline for Characterizing and Evaluating a Candidate Project Site for Solar Thermal Applications"

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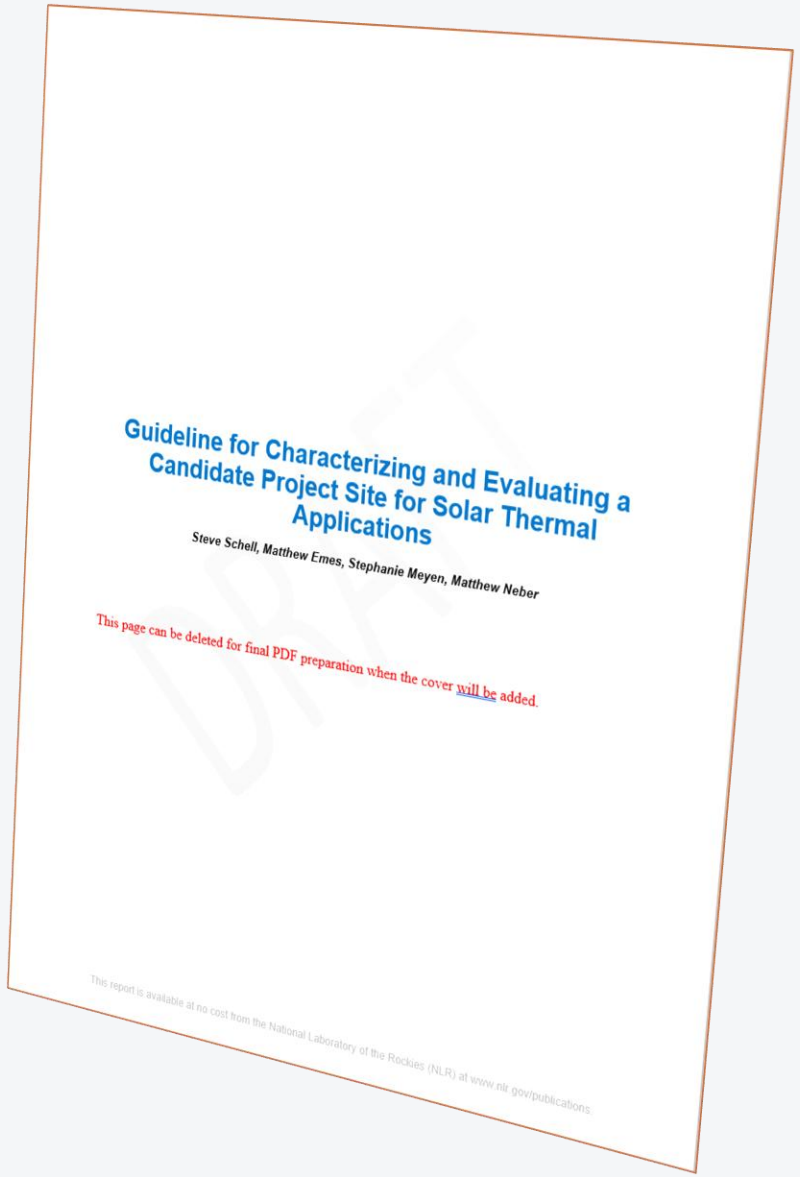
INTRODUCTION

- Guideline to be published soon
- Comprehensive guide for technical, environmental, and regulatory site assessment for CSP and SHIP projects



PURPOSE & SCOPE

Purpose

- Establish a common approach to CSP and SHIP site evaluation
- Identify constraints & challenges early
- Reduce risk through standardization
- Support transparent decision making

Scope

- Geography: USA, high-DNI
- Technology: Concentrating solar, including heliostats, parabolic troughs, dish concentrators
- Application: Power generation (CSP) and process heat (SHIP), with or without storage
- Scale: Pilot, demonstration, and commercial

WHY?

Permitting surprises are expensive!

Unique development considerations for concentrating solar thermal projects

Images are AI generated.

OVERVIEW

Site Screening

1. Solar resource assessment
2. Land evaluation
3. Zoning and land use
4. Exclusion zones

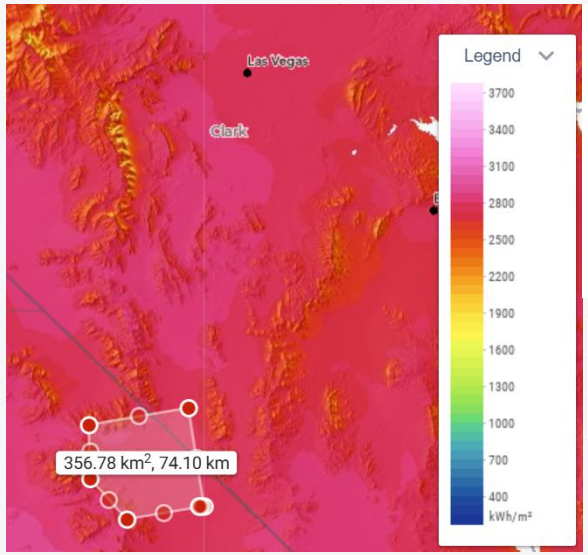
Go / No-Go

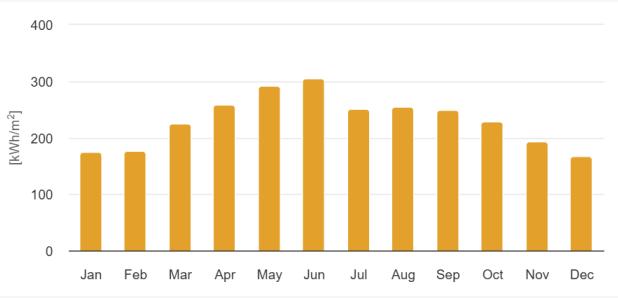
Detailed Site Evaluation

- Solar resource
- Meteorological
- Land
- Environmental & regulatory
- Grid interconnection & electrical
- Water supply & discharge
- Access, logistics, & infrastructure
- Community engagement
- Cost & risk
- Performance modeling

Go / No-Go

SITE SCREENING: LOW-COST GO / NO-GO





Direct normal irradiation	DNI	2785.8	kWh/m²
Global horizontal irradiation	GHI	2108.1	kWh/m²
Diffuse horizontal irradiation	DIF	456.7	kWh/m²

$$E_{annual} = DNI_{annual} \times A_{land} \times GCR \times \eta_{so,avg} \times \eta_{ot} \times \eta_{te}$$

$$P = 1{,}000\ \frac{W}{m^2} \times A_{land} \times GCR \times \eta_{so,peak} \times \eta_{ot} \times \eta_{te} \times k_{TES}$$

What are we looking for?

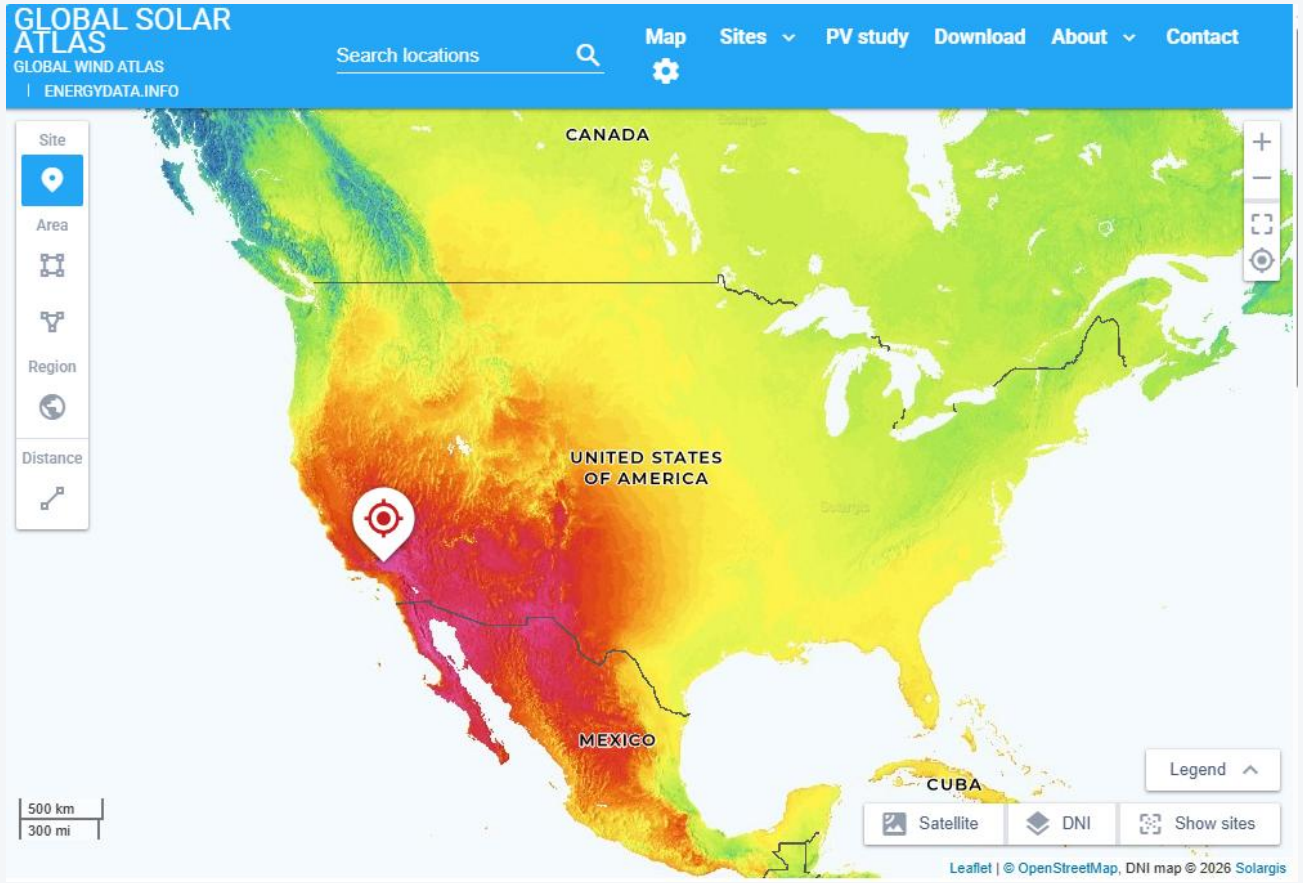
- Great DNI: min 1,900 to 2,200 kWh/m²/year
- Sufficient land to produce target energy and power
- No land use roadblocks
- No obvious exclusion zones (protected lands, tribal lands, critical habitat areas, etc.)

SOLAR RESOURCE ASSESSMENT: ESTABLISH THE POTENTIAL

Solar resource defines the energy generation potential of the project

- Source: satellite, ground-based networks, regional archives
- Temporal resolution: Hourly only sufficient for screening, 1-, 5-, or 15-minute intervals better
- Duration: 10-20 years of history

On-site measurement campaign?



Screenshot from the Global Solar Atlas

METEOROLOGICAL ASSESSMENT: LIMITATIONS ON PERFORMANCE

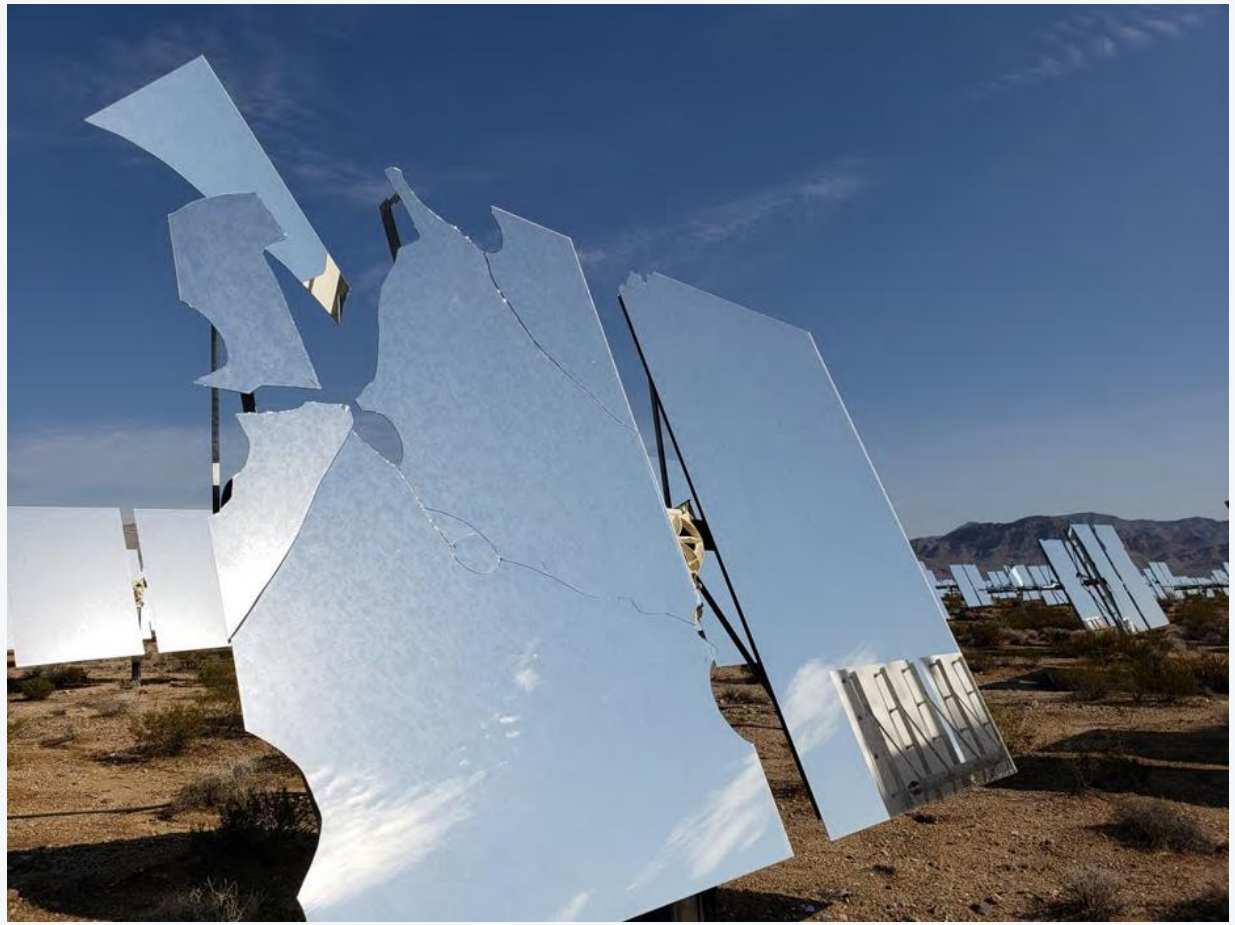


Photo from Ivanpah 2018 annual compliance report

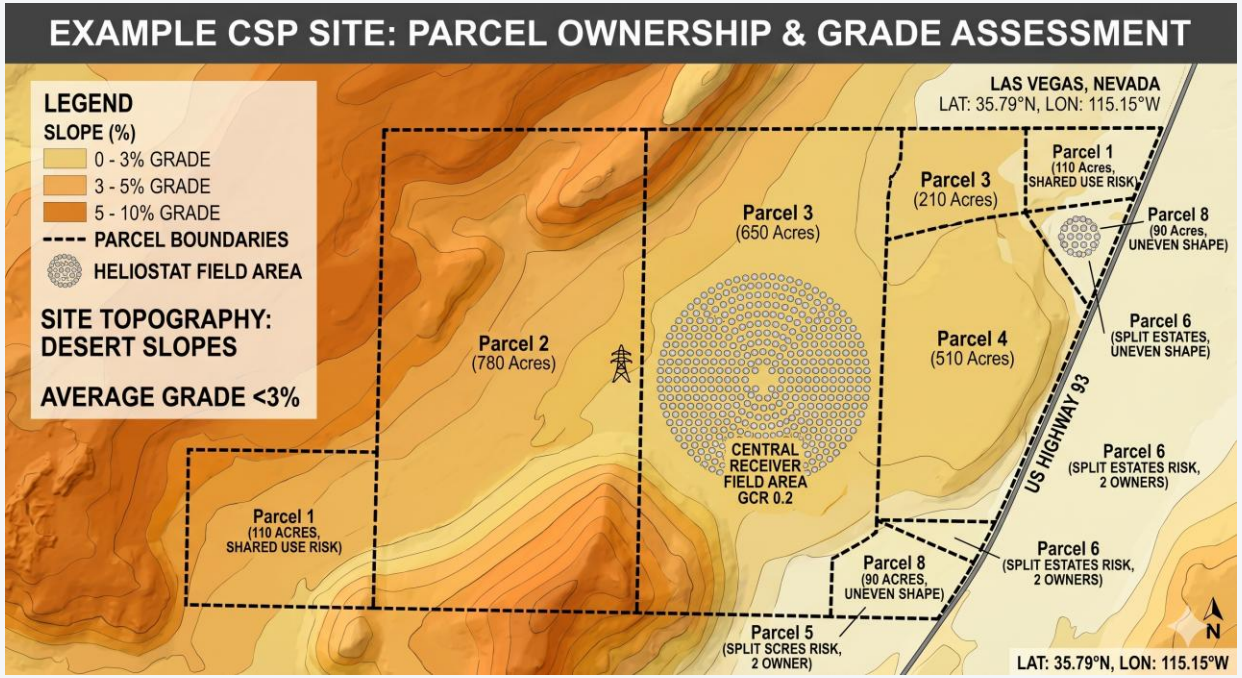
Meteorological conditions limit performance and operating hours

- Wind: operating and survival
- Temperature and humidity
- Soiling & airborne particles
- Extreme events (rain, hail, snow, sand/dust)

LOCATION, LOCATION, LOCATION!

Favorable characteristics for a solar thermal project site

- Parcels are large & contiguous, with simple ownership
- Grade <5% over solar field area (<3% preferred)
- No obvious geotechnical risks (e.g. expansive soil, liquefaction)
- No obvious hydrological risks (floodplain, evidence of erosion)



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ENVIRONMENTAL & REGULATORY CONSIDERATIONS

Solar thermal project development requires navigating a complex web of environmental and regulatory requirements

Federal, State, and Local Permitting Requirements	Endangered Species	Cultural / Archaeological
Visual Impact, Glint & Glare	Height Limitations & Airport / Flight Path Considerations	Proximity to Department of Defense Facilities

Image sources: Hydropower Reform Coalition, Wikipedia, Wikipedia, US DOE, AI generated, Jenicek, Elisabeth & Fournier, Donald & Goran, William & Downs, Natalie & Sagert, Adams. (2004). The Sustainable Installation Regional Resource Assessment (SIRRA) Capability. Version 1. 155.

ELECTRICAL INTEGRATION: UTILITY-SCALE POWER VS BTM THERMAL

Grid-Connected CSP		On-Site SHIP
Nearest utility substation location & specs, ROW availability, environmental or permitting constraints along path.	Siting & Proximity Constraints	Map host facility's infrastructure, evaluate on-site capacity for supporting SHIP system loads.
Use utility studies to screen nearby substations for queue congestion and indicators of upgrade costs. Expect formal, multi-stage review timeline.	Capacity Assessments & Study Workflows	Evaluate host plant's long-term load growth.
Assess known congestion or curtailment issues in the region, analyze grid stability, ramping, inertia deficits, etc. Assess value of TES dispatch.	System Dynamics & Risk Mitigation	Audit historical outage frequency of host facility's grid connection, establish backup power requirements.

WATER: ARID SITING REALITIES & COOLING TRADE-OFFS

SOURCING	CONSUMPTION	DISCHARGE
• Allocation Audit • Quality Risks (TDS / Silica) • Mass Balance • Treatment Requirements	• Dry Cooling Baseline • Summer Penalty • CSP vs SHIP Sensitivity	• Evaporation Ponds • NPDES* Permitting • Brine / Sludge Liability

*National Pollutant Discharge Elimination System

PEOPLE, EQUIPMENT, & MATERIAL IN REMOTE LOCATIONS

FREIGHT

- International ports
- Rail infrastructure
- Last-mile bottlenecks

Image Credit

ON-SITE LOGISTICS

- Laydown & pre-assembly
- Temporary utilities
- Shared access & activity (esp. SHIP)

Image Credit

SOURCING & WORKFORCE

- Sourcing premium
- Workforce housing
- O&M skilled labor

Image Credit

COMMUNITY ENGAGEMENT

SOCIAL LICENSE TO OPERATE

Community sentiment is not a public relations task; it is a critical path regulatory requirement.

A single unengaged stakeholder or unmitigated visual impact can halt a project.

ADJACENCY & SENTIMENT FLASHPOINTS

- Proximity Audit
- Public Perception Variables
- Historical Precedents

REGIONAL ECONOMIC OPTIMIZATION

- Incentive Capture
- Local Supply Integration
- Workforce Pipelines

Image Credit

SITE-DRIVEN IMPACTS ON PROJECT COST AND RISK

Site Evaluation Factor	Capex Implications	Opex Implications
Civil & Earthworks	Grading, cut-and-fill volumes, foundation designs, and stormwater drainage	Ongoing erosion control, scour mitigation, and stormwater basin maintenance
Electrical Infrastructure	Tie-in distance, substation upgrades	Purchased power cost
Water	Supply distance, cooling system cost, treatment & storage infrastructure	Cooling parasitic loads & efficiency penalties
Labor & Logistics	Construction wage rates, mobilization costs, productivity. Material & equipment delivery	Operator & technician availability & wage rates
Permitting & Mitigation	Environmental studies, mitigation measures	Ongoing monitoring, compliance

Technical Risks
- Resource uncertainty
- Extreme weather
- Geotechnical variability
- …

Regulatory Risks
- Permitting timelines
- Environmental constraints
- Stakeholder opposition
- …

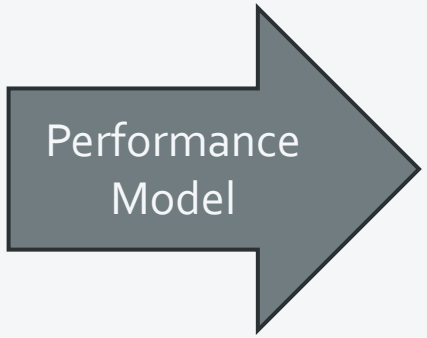
Scheduling Risks
- Long-lead approvals
- Interconnection studies
- Seasonal construction windows
- …

Operational Risks
- Soiling
- Water availability
- Grid curtailment
- Process integration risk
- …

SCREENING-LEVEL 8760 PERFORMANCE MODEL

Model Inputs & Boundary Conditions

- Site Conditions: Multiyear solar resource datasets, uncertainty ranges, site-specific meteorological effects
- Technology Sizing: Field layout, receiver geometry, optical-to-thermal efficiencies, TES capacity
- Power Block / Process Heat Parameters: Efficiency curves, dispatch constraints / strategies
- Conservatism: Preliminary modeling should explicitly bias toward the conservative end of uncertainty ranges



Simulation & Long-Term Outputs

- 8760 Baseline: Hourly annual production model utilizing representative weather year (TMY) to establish baseline yield
- Ramp-Up & Commissioning: Model performance ramp over early years, reflecting ongoing commissioning activity and operational refinements
- Degradation Curves: Incorporate distinct long-term degradation factors – mirror reflectivity, receiver efficiency, etc.
- Techno-economic Readiness: Output data should be formatted for easy incorporation into project financial models

Critical outputs include P50 and P90 annual energy yield estimates

STANDARDIZED REPORTING & DECISION GATES

Standardized Reporting

- Report template defined before work begins, ensuring consistency
- Site package includes standardized summary tables (DNI, meteo, water, grid)
- Includes prioritized, living risk register including technical and regulatory risks & mitigation summaries

Go / No-Go Gate

- GO: No fatal flaws; project clears to formal feasibility
- CONDITIONAL GO: Viable asset, pending resolution of isolated data gaps or risks
- NO-GO: Insurmountable fatal constraints or unmitigated risks identified; drop site immediately

Path forward:

- Initiate detailed feasibility studies
- Launch permitting and interconnection processes
- Begin FEED study

- Site selection has strong correlation with project success
- Oversights become more costly as the project progresses
- Every project is unique, and every organization has different priorities and sensitivities

  → *Use judgement following this guideline!*

SCHELL INNOVATION VENTURES

GROUNDED IN FIRST PRINCIPLES. PROVEN IN THE FIELD.

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