U.S. Department of Energy

HelioCon

Heliostat Consortium for Concentrating Solar-Thermal Power

Summary of an Initial Heliostat Supply Chain Analysis

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

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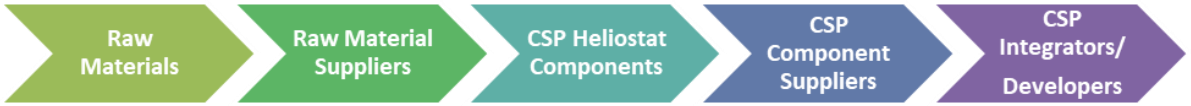
1. Heliostat Supply Chain and Main Glass Suppliers



- CSP supply chain is primarily composed of commodity materials e.g., steel, Al, and glass
  - This presentation and paper focuses on heliostat suppy chain
  - The report looks at other areas like domestic component suppliers
- Key Glass Suppliers
  - Main suppliers are AGC Glass, Cosin Solar, Flabeg Solar, Guardian Glass, and Rioglass
  - Germany, Spain and China are currently the biggest global suppliers
  - U.S. has domestic production, though limited
    - Manufacturing has shut down due to lack of demand

Key Suppliers	Country where manufacturing is located	Heliostat project references	Power Tower Type
AGC Glass Europe	Europe e.g., Germany and Spain	Ashalim Plot B/ Megalim (Israel)	Direct steam
Cosin Solar/ Damin Glass	China	Supcon Solar (China)	Molten salt
		Gonghe (China)	Molten salt
Flabeg Solar	Germany (and U.S. prior*)	Crescent Dunes (U.S.)	Molten salt
		Sierra Sun (U.S.) Tower	Direct steam
		Hami (China)	Molten salt
		Redstone (South Africa)	Molten salt
Guardian	Unites States	Gemasolar (Spain)	Molten salt
		Ivanpah (U.S.)	Direct steam
Rioglass Solar	Belgium, Spain and South Africa (and U.S. prior*)	Noor III (Morocco)	Molten Salt
		Noor Energy 1 (United Arab Emirates, UAE)	Molten salt
		Khi Solar 1 (South Africa)	Direct steam
		Atacama 1 (Chile)	Molten salt

2. Challenges and Opportunities in Manufacturing and the Heliostat Supply Chain

- **Supply Chain and Manufacturing Challenges:**
  - Inconsistent demand and pipeline
    - High minimum scale precision manufacturing creates creates particular challenges
    - Volatile demand due to the small size of the global CSP industry
      - ~6 GW in total installed capacity
      - Lengthy development cycles
      - Large project sizes relative to total market size
    - In the last decade, the CSP market in general, the annual year-on-year global installed capacity growth decreased significantly
  - Global supply chain disruptions
    - COVID19 has significantly affected supply chains
    - Labor shortfalls in countries such as China, South Africa and UAE, where CSP plants were in construction in 2020
  - Uncertain U.S. and global growth prospects
    - Not on track for Net Zero scenario from IEA

- **Supply Chain and Manufacturing Opportunities:**
  - Several opportunities exist for CSP heliostat manufacturing to meet global near term demands
    - In regions like China, Africa, MENA, and the Middle East over the next 3-5 years
  - Globally significant additional research, innovation, commercialization efforts, and market development are needed for CSP (both parabolic troughs and power towers) to become globally competitive with other generating technologies
  - Use in other markets:
    - Industrial Process Heat (IPH) e.g., Heliogen and DLR are developing solutions
    - Solar fuels e.g., Synhelion
    - Solar driven cement e.g., Cemex partnership

3. Heliostat Jobs Impacts and CSP Potential for 2050

- Estimated jobs (direct and indirect) for a heliostat field
  - Commercial
    - Glass: 94
    - Steel: 94
  - Future jobs
    - 100 heliostat fields:
      - Glass: ~9,480
      - Steel: ~6,760 – 8,840
- 0.5 M – 1.5 M jobs for solar PV by 2035 (Solar Futures Study)
  - Dependent on the scenario
- Estimated jobs from the potential of 39 GW of CSP from the study
  - Based on molten salt power towers with 6hrs of storage
  - ~500 direct and indirect jobs per plant
  - 195,000 jobs (direct and indirect), for ~390 CSP plants in the U.S.

Recent Heliostat Analysis, Material	Metric Tons (MT)	Estimated Jobs in sector in 2020	Direct Jobs per field based on the MT of material produced in 2020	Indirect Jobs per field in 2020
Glass, in Turchi et al. 2015 heliostat field	10,055	87,850	44	47
Commercial Design, Glass	10,786	87,850	**47**	**47**
Advanced Design, Glass	10,800	87,850	**47**	**47**
Steel, in Turchi et al. 2015 heliostat field	16,584	72,230	16	68
Commercial Design, Steel	13,343	72,230	13	54
Advanced Design, Steel	17,443	72,230	17	71

Material/Area	Metric Tons of Material (MT) for single field	Direct and Indirect potential Jobs for 100 heliostat fields	Direct and Indirect potential jobs for 1,000 heliostat fields
Commercial Design, Glass	10,786	**9,480**	94,798
Advanced Design, Glass	10,800	**9,486**	94,860
Commercial Design, Steel	13,343	**6,761**	67,609
Advanced Design, Steel	17,443	**8,838**	88,384

4. Material Content Analysis (focused on U.S.)

- Analysis found in the report
- Single heliostat field is minor in the scale of the U.S. production
  - e.g., 0.05% for glass production
- Material content analysis
  - Glass
    - Commercial Design: 10,786 MT
    - Advanced Design: 10,800 MT
    - Estimated value ~$13 M per heliostat field
  - Steel
    - Commercial Design: 13,343 MT
    - Advanced Design: 17,443 MT
    - Estimated value ~$16-21 M per heliostat field

Recent Heliostat Analysis, Material	Metric Tons (MT)	Annual U.S. Production (MT) in 2020	Percent of U.S. production (%) in 2020	Estimated Value of Sector in 2020 ($B)	Estimated Value of material in heliostat field in 2020 ($)
Glass, in Turchi et al. 2015 heliostat field	10,055	20,000,000	0.05028%	25.0	$12,568,750
Commercial Design, Glass	**10,786**	20,000,000	**0.05028%**	25.0	$13,482,500
Advanced Design, Glass	**10,800**	20,000,000	**0.05028%**	25.0	$13,500,000
Steel, in Turchi et al. 2015 heliostat field	16,584	72,700,000	0.02281%	91.0	$20,758,514
Commercial Design, Steel	**13,343**	72,700,000	0.01835%	91.0	$16,701,692
Advanced Design, Steel	**17,443**	72,700,000	0.02399%	91.0	$21,833,741

5. Annual Technology Baseline (ATB) 2022 Analysis

Overnight Cost of Capital (OCC) and CAPEX from ATB 2022 projections in 2035 and 2050

ATB 2022 Scenario	Year	Turbine Capital Cost ($/kWe)	Storage Capital Cost ($/kWe)	Field Capital Cost ($/kWe)	ATB 2022 OCC ($/kWe)	ATB 2022 CAPEX ($/kWe)
Base	2020	1,910	767	3,566	**6,242**	6,505
Moderate	2035	1,242	499	2,318	**4,059**	4,230
Advanced	2035	965	388	1,802	**3,155**	3,288
Moderate	2050	1,143	459	2,135	**3,737**	3,894
Advanced	2050	814	327	1,519	**2,659**	2,771

- 2022 ATB
  - 2020 start point
  - $6,242/kWe Overnight Capital Cost
    - Turbine: $1,910/kWe
    - Storage: $767/kWe
    - Field: $3,566/kWe
- 2035 OCC
  - Moderate: $4,059/kWe
  - Advanced: $3,155/kWe
- 2050 OCC
  - Moderate: $3,737/kWe
  - Advanced: $2,659/kWe

https://atb.nrel.gov/electricity/2022/concentrating_solar_power

6. Summary

- Publication
  - Parthiv Kurup, Sertaç Akar, Chad Augustine, and David Feldman. 2022. “Initial Heliostat Supply Chain Analysis”. NREL. Published - https://www.nrel.gov/docs/fy22osti/83569.pdf
- Take aways:
  - The heliostat supply chain is primarily composed of plentiful commodity materials e.g., Al, steel, and glass
  - Few large suppliers of key components like glass and mirrors
    - U.S. domestic supply for steel and commodities exists
  - The lack of a near-term U.S. market is a formidable challenge to domestic CSP heliostat manufacturers.
  - CSP deployment is expected to grow in regions like China, Africa, and the Middle East over the next 3-5 years
  - 195,000 jobs (direct and indirect) potentially associated with 39 GW of capacity in U.S.
- Recommendations, and impacts of the work
  - Future further detailed analysis e.g., mapping the supply chain and connecting it to other technologies
  - Feeds into the HelioCon ‘Advanced Manufacturing’ topic. The ‘HelioCon Roadmap’ is released

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Thank you. Questions?

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