



U.S. DEPARTMENT
of **ENERGY**

Office of Critical Minerals
and Energy Innovation

Integrating Solar Heat for Industrial Processes into American Facilities

Matthew Bauer: IESO - Thermal Energy Systems **Program Manager**

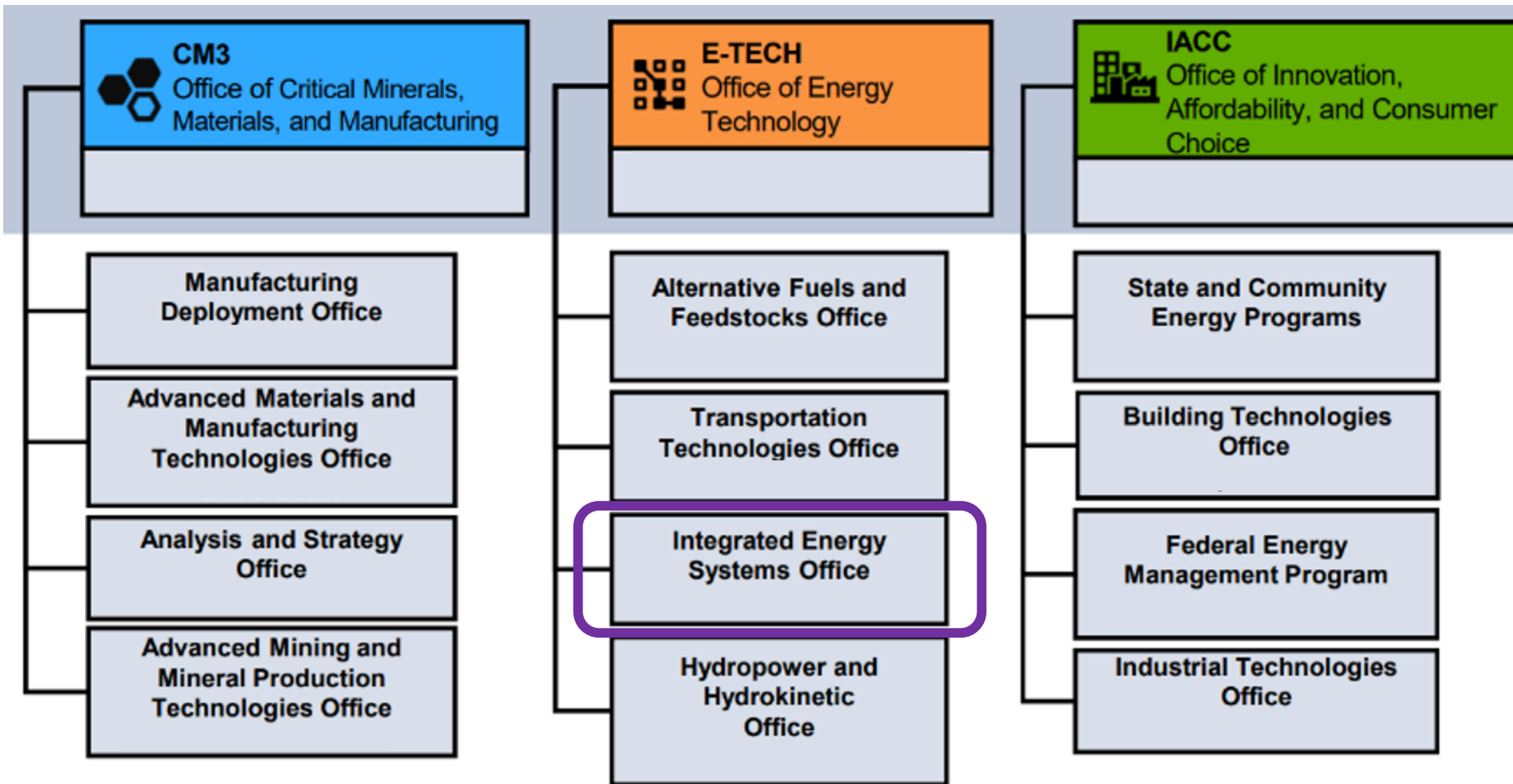
James Ma: IESO - Thermal Energy Systems **Technology Advisor**

Thermal Mechanical Chemical Energy Storage Workshop

July 29, 2026. Charlotte, NC.



DOE Reorganization: EERE has become CMEI



Solar, Wind, and Grid integration budgets operate within IESO.

Major DOE civilian R&D Department Elements by FY26 Budget:

- Science: \$8B
- **CMEI: \$2B**
- Nuclear Energy: \$2B
- Hydrocarbons & Geo: \$650M
- ARPA-E \$350M

About \$14B of DOE's \$49B FY26 Budget

Integrated Energy Systems Office (IESO) Overview

MISSION

The Integrated Energy Systems Office drives strategic research and development of advanced energy solutions, focusing on enhancing grid reliability and resilience, fostering U.S. technological leadership across diverse energy generation sources, and reducing the cost of energy for Americans.

VISION

The Integrated Energy Systems Offices strives to enable a secure, integrated, and affordable energy future—powered by innovation and built to serve all Americans.



Integrated Energy Systems Office Objectives

1

Solar in Space Initiative: Establish the United States as the global leader in space-based solar power generation and advanced photovoltaic material science, significantly contributing to national energy security, reducing the cost of electricity, and advancing next-generation energy systems.

2

Wind and PV Systems Recycling: Establish successful and economical recycling for wind and solar energy technologies, significantly reducing waste, recovering critical materials, and reduce cost of PV and wind component recycling.

3

Grid Integration, Data, Interconnection, and Cybersecurity: Develop advanced grid data and technology including AI to support rapid load growth, address technical challenges, and enable expedited and cost-effective grid infrastructure expansion while enhancing the reliability and cyber-physical security of the power system.

4

Solar Heat for Industrial Process (SHIP): Grow the US fuels, chemicals, mining, and industrial sectors by developing turnkey, American manufactured solar thermal systems with applications including produced water desalination, remote mining, fuel conversion, growth of the food and beverage industry, and manufacturing.

5

Maximize Performance and Reduce Costs: Improve long-term reliability and performance of existing energy assets through AI and other advanced technologies, apply wind and solar capabilities to high-priority applications, and support domestic manufacturing, optimized O&M, and a highly skilled workforce.

6

Permitting and Impact Reduction: Develop data and tools, AI applications, scientific research, and best practices to reduce permitting time, increase certainty, and reduce the negative impacts of energy development on people and the environment.

Maturing CSP Industry

Commercial Concentrating-Solar Thermal Plants

Solana's Generation Station (280 MW_e)
1.5 GWh_e Thermal Energy Storage



Solar Reserve's Crescent Dunes (100 MW_e)
1.1 GWh_e Thermal Energy Storage



SunVapor's Two SHIP facilities for
Dimethyl Ether Production & Almond
Processing

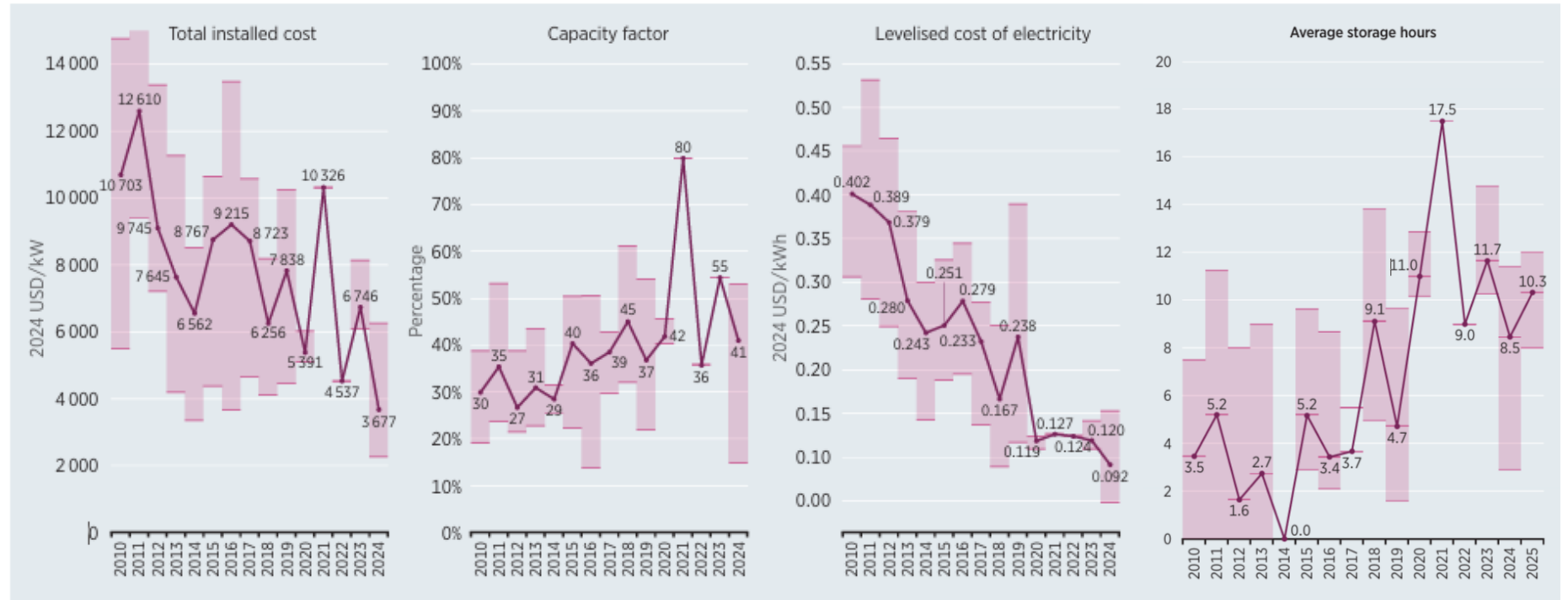


<https://www.youtube.com/watch?v=mlzNQSmbUpA>

Concentrating Solar Power 15-year trend

Figure 5.1 Global weighted average and range of total installed costs, capacity factors and LCOEs for CSP, 2010-2024

- LCOE down 77%
- Capacity factor up 37% due to TES
- Average of 8.5 hours of TES for projects commissioned in 2024
- Generational change from thermal oil plants to molten salt plants
- Learning curve and repeat deployment is occurring in China.



Notes: kW = kilowatt; kWh = kilowatt hour; USD = United States dollar.

Renewable Power Generation Costs in 2025. IRENA

Concentrating Solar Power 15-year trend

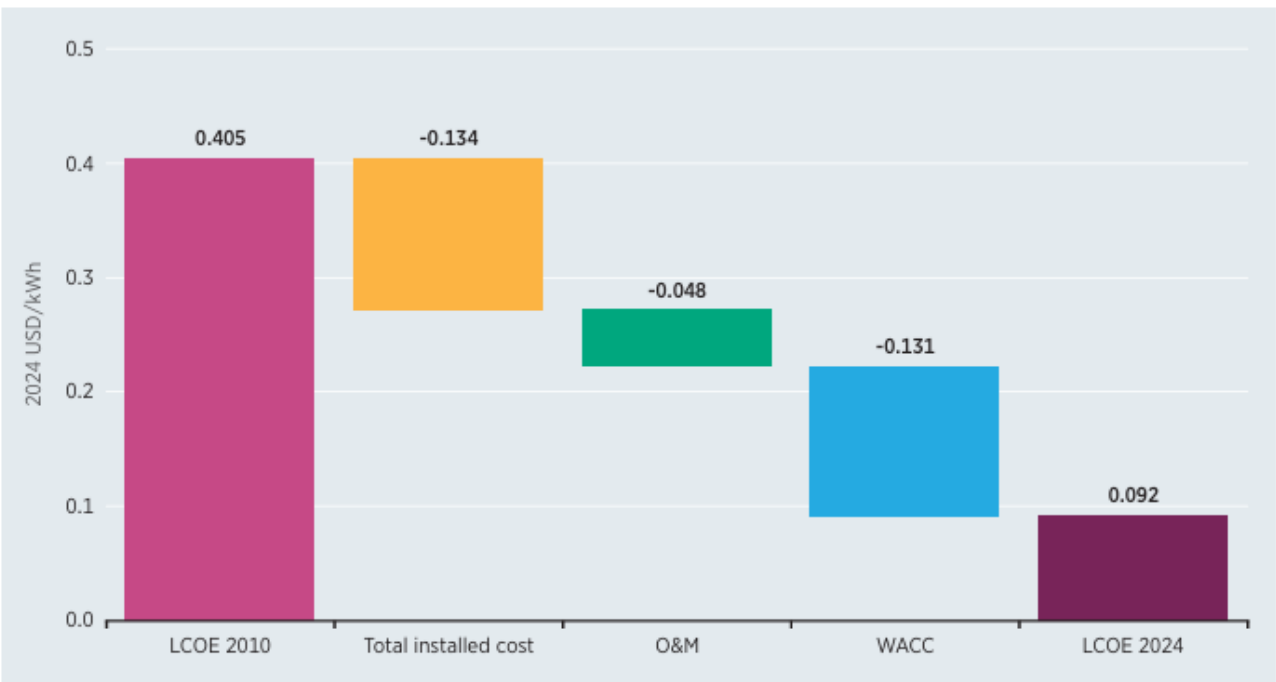
Figure 5.3 Capacity factor trends for CSP plants by DNI and storage duration, 2010–2024



Source: (CSP.guru, 2025; World Bank Group *et al.*, 2025).

Notes: DNI = direct normal irradiance; h = hour; kW = kilowatt; kWh = kilowatt hour; MW = megawatt; m² = square metre; USD = United States dollar.

Figure 5.6 Reduction in LCOE for CSP projects by source, 2010–2024



Notes: LCOE = levelised cost of electricity; O&M = operation and maintenance; kWh = kilowatt hour; USD = United States dollar; WACC = weighted average cost of capital.

Renewable Power Generation Costs in 2025. IRENA

Results of China's Policy led CSP build out

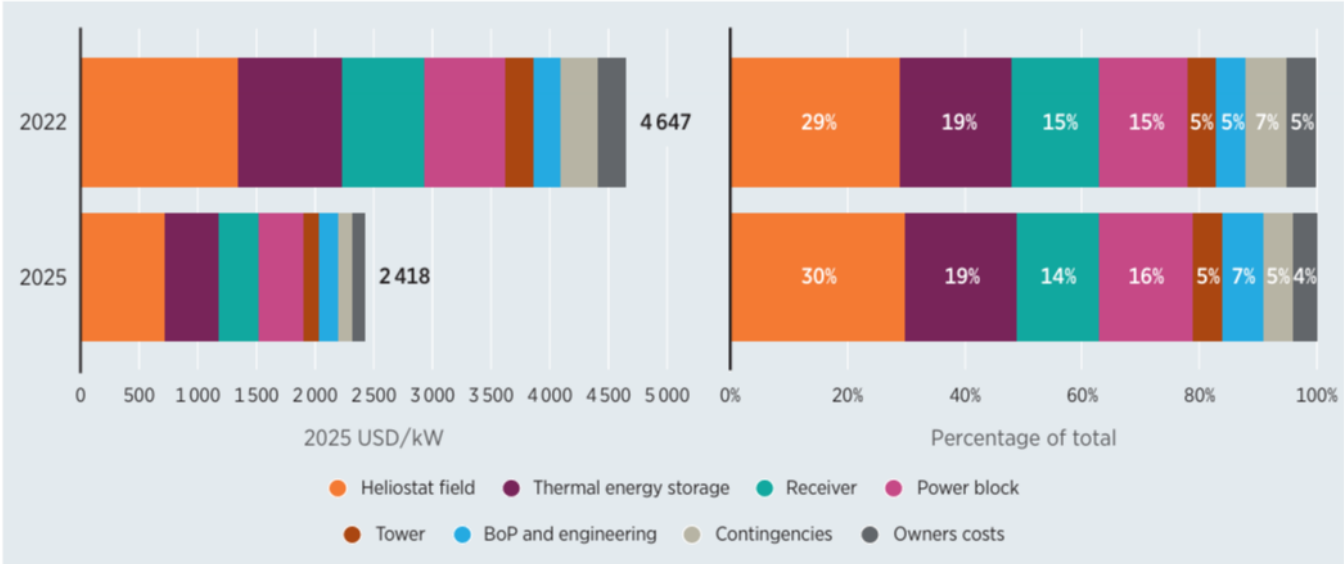
Build Phase	Installed Capacity	# of plants	LCOE \$/kWh	Power Block Size	Thermal Storage Size	Capacity Factor
2015-2021	1 GW	10	~0.17	50-100 MW	0-8 hours	35%
2022-2025	1.7 GW	27	0.08-0.10	100 MW	8-12 hours	50%
2026-2030	15 GW (Target)	>100 (Target)	0.055-0.07 (Target)	> 200 MW	10-16 hours	60%

As of June 2026, China has 30 power plants with > 5 GW of capacity under construction. **CSP is now a similar cost as energy from Chinese Coal plans.**

Many of the 2026+ plants will allow the grid to also charge thermal energy storage, adding value to the plants.

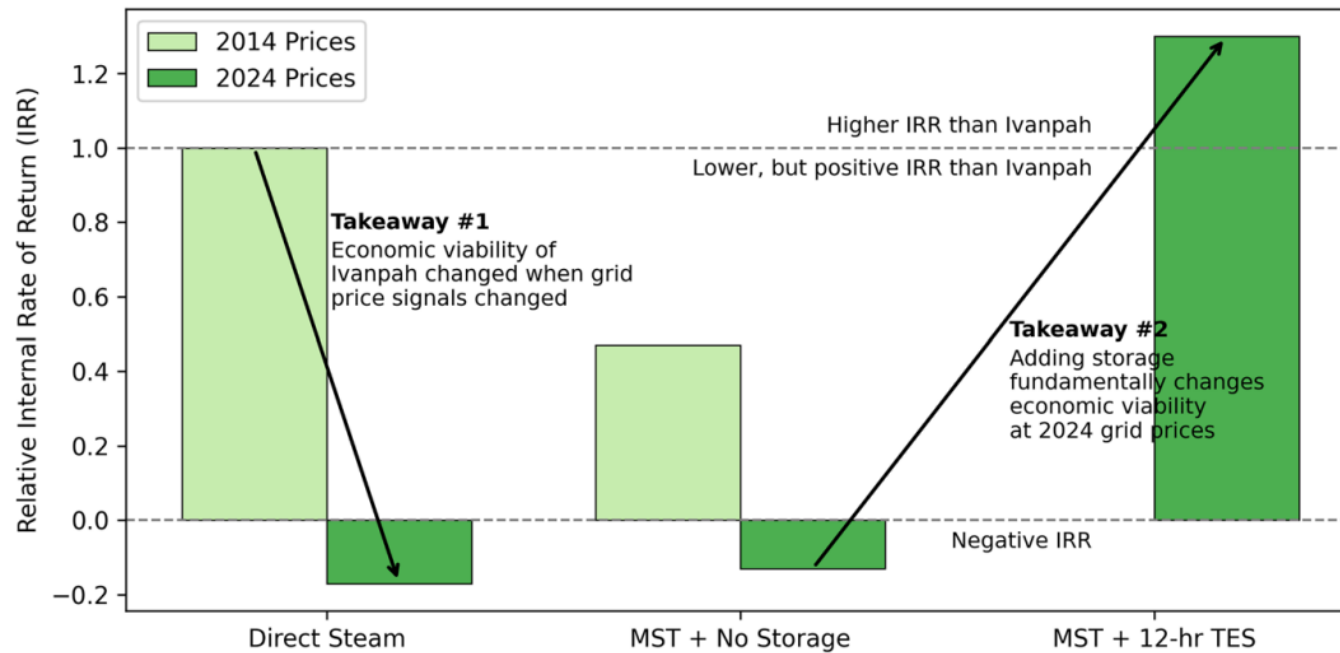
With a learning curve and supply chain development CSP becomes a cost competitive technology. Similar to Nuclear and Geothermal, it requires significant scale.

Figure 5.2 TIC breakdown for ST projects in China, 2022 and 2025



Notes: kW = kilowatt; USD = United States dollar.

Thermal Energy Storage would have made Ivanpah a first of a kind success story



Mojave Desert- California. 392 MW_e

It has taken iterations and failures to mature molten salt thermal energy storage

Failure Analysis Energy Storage Plants

Julian D. Osorio,¹ Mark Hank Price,² Jose Torres Cesar Nieto-Londono,⁴ and Janna Martinek¹

Understanding failure in salt storage in CSP appl

Sergio Andrés Ardila-Parra^a, C

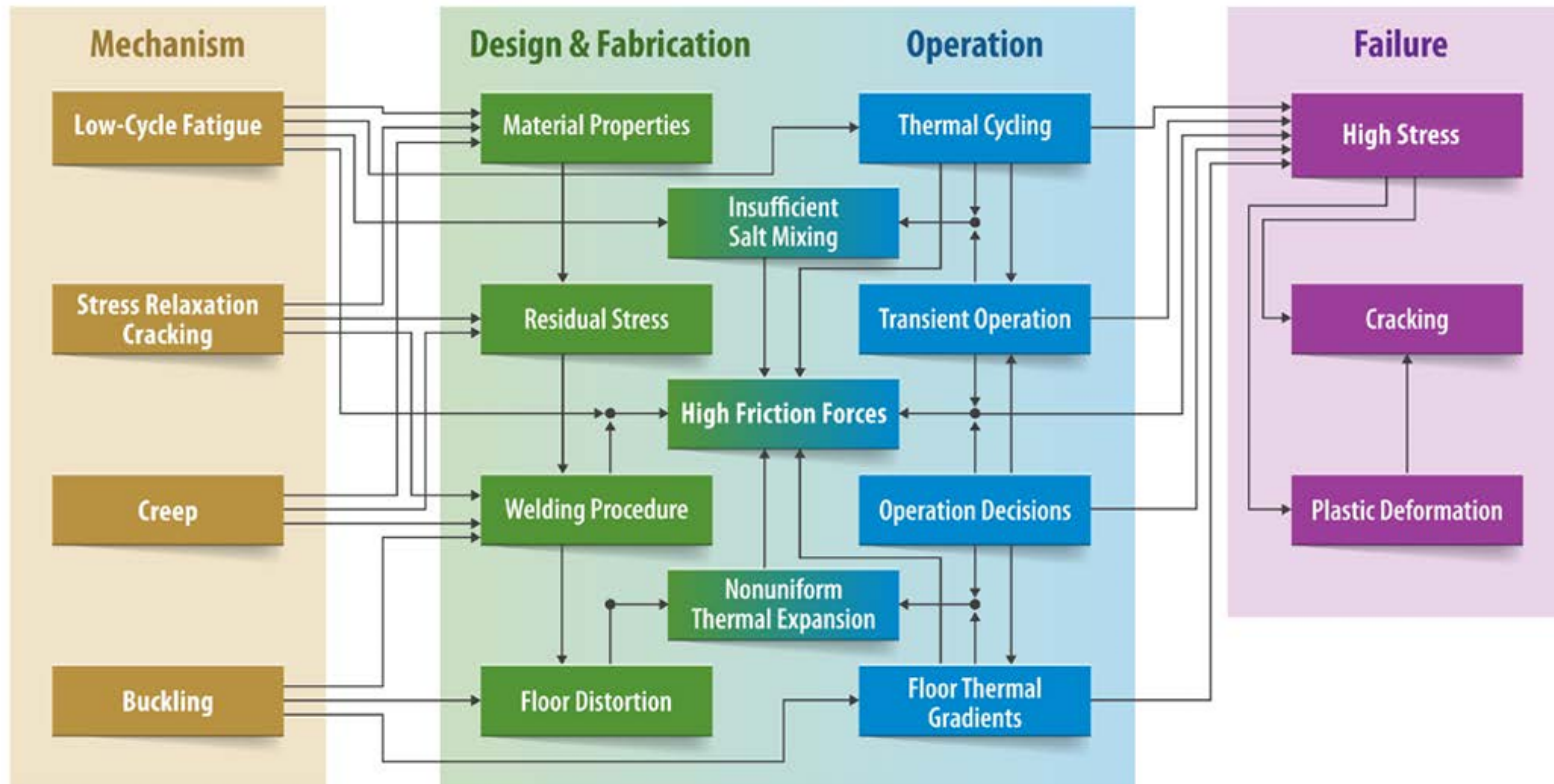


Figure 4. Failure behaviors in SS 347H molten salt hot tanks

Complicate Floor Buckles Tanks

Price, David Cubel, Sergio Davila, Art Drewes

Owner's or Nitrate acts

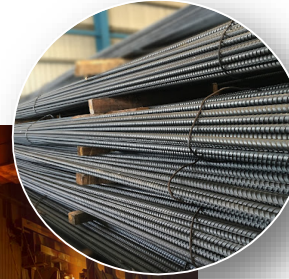
SHIP Opportunity

Many industrial processes need heat

Cement



Steel



Pulp & paper



Chemicals



Food & beverage

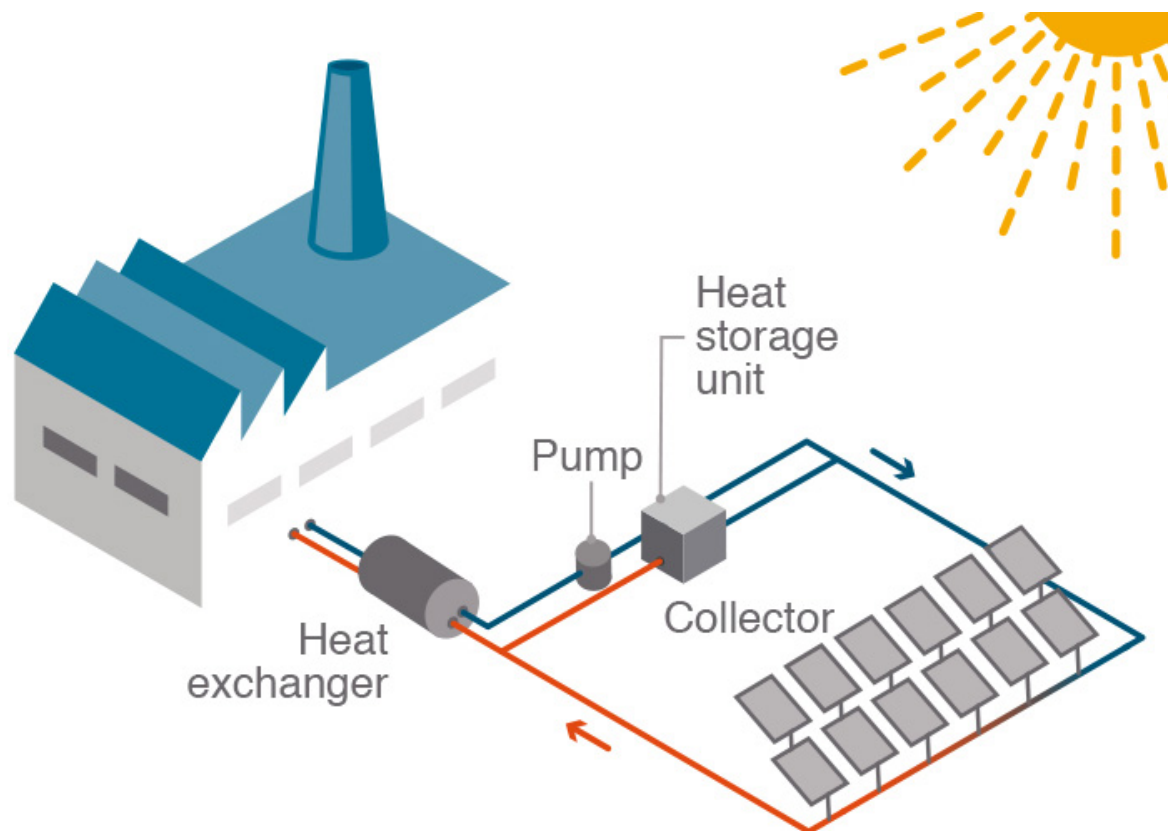


Oil refining

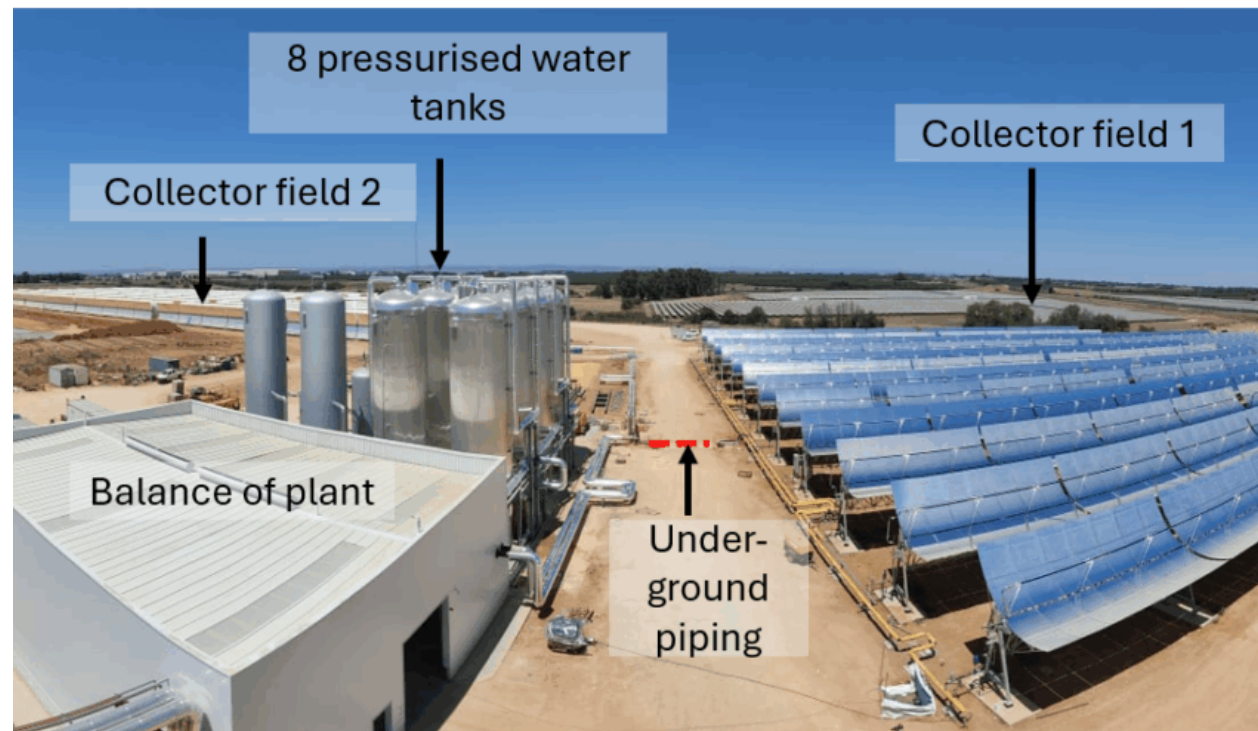


SHIP systems are conceptually straight forward

SHIP technologies collect and concentrate sunlight to deliver heat to a variety of industrial applications, like water desalination, food processing, chemical production, and mineral processing. They use thermal storage to provide energy on demand.



Example SHIP system diagram. [Source](#)

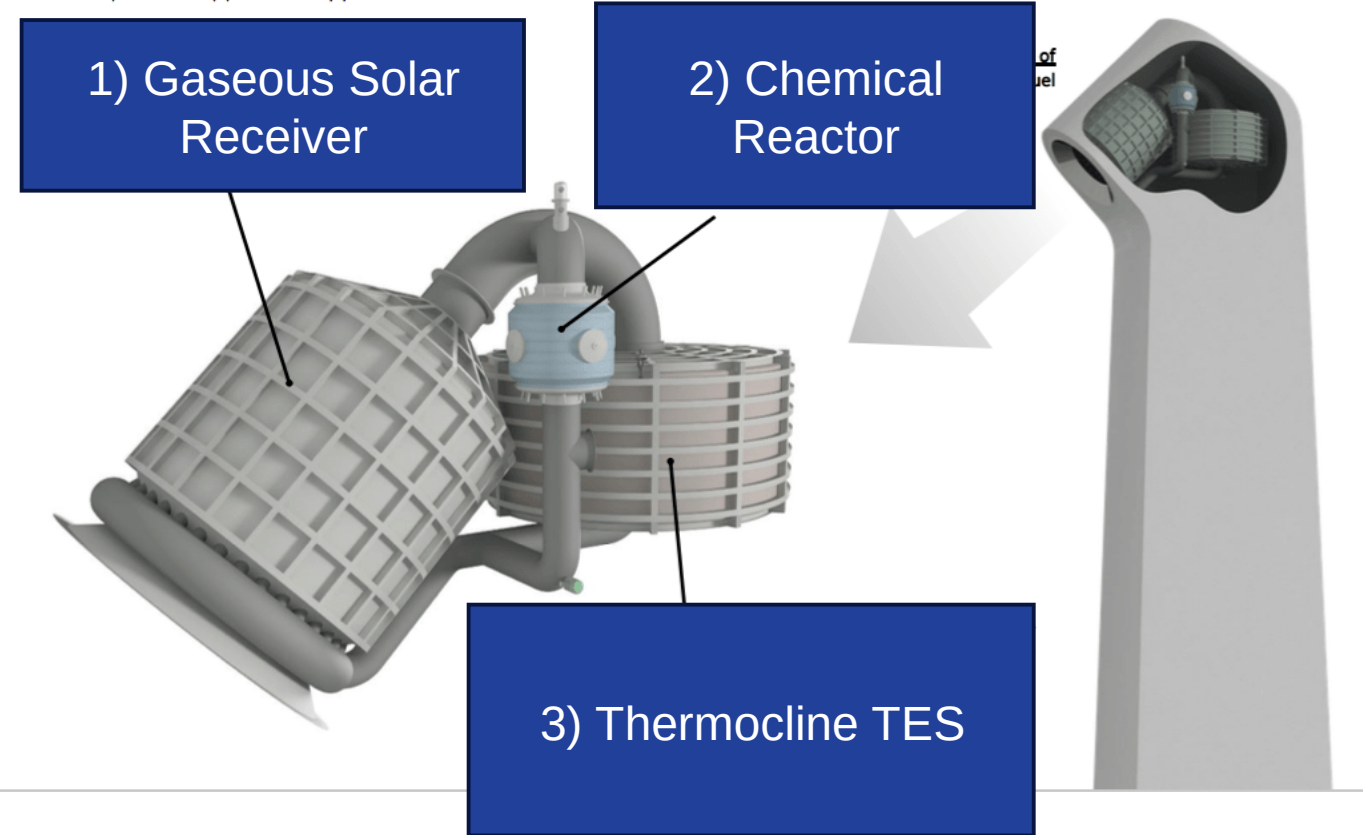


Existing 30 MW SHIP system at a Heineken facility in Seville, Spain. [Source](#)

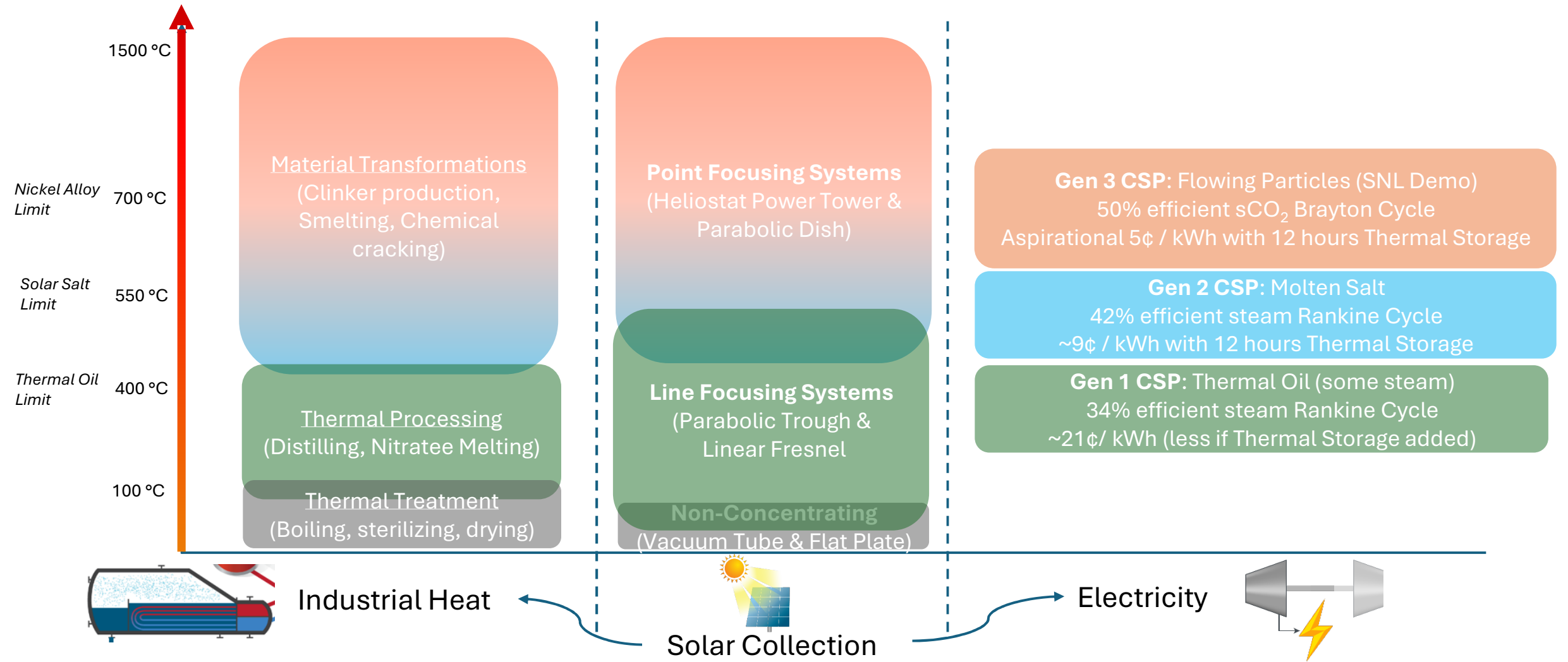
Synhelion & German Aerospace Research Center generating Jet Fuel at 1500 °C

SYNHELION TECHNOLOGY – THE 3 INNOVATION FRONTS

The solutions of Synhelion are based on the combination of 3 nearly-independent innovation fronts, all of which have independent application opportunities.



Leveraging CSP Technology for SHIP



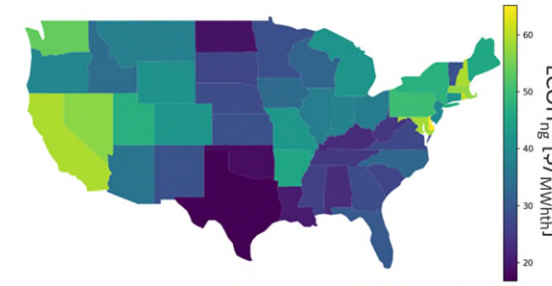
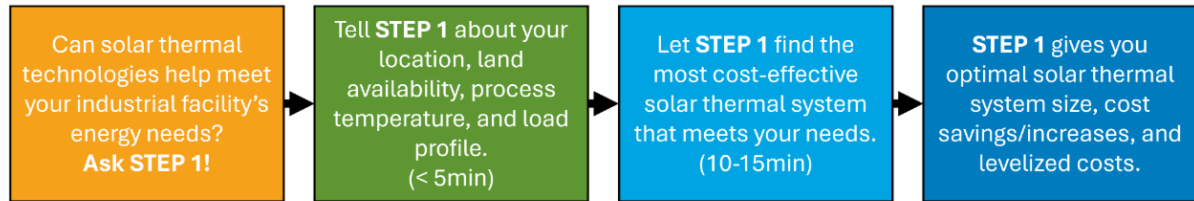
Leveraging CSP technology for SHIP



Analysis on select favorable SHIP markets in the US

STEP1 WORKFLOW

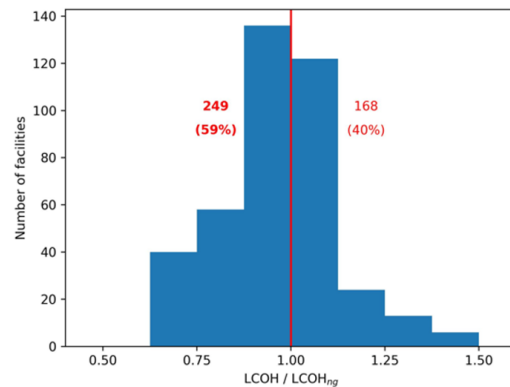
SOLAR THERMAL ENERGY PLANNER



Rank	State	LCOH _{ng}
1	Hawaii**	\$ 128.05
2	Delaware	\$ 65.20
3	Rhode Island**	\$ 60.01
4	New Hampshire**	\$ 59.30
5	California	\$ 59.26 (66.05*)
...		
25	Ohio	\$ 37.09
...		
46	Kentucky	\$ 22.88
47	Louisiana	\$ 20.42
48	North Dakota	\$ 19.18
49	Oklahoma	\$ 18.45
50	Texas	\$ 16.75

*Assuming \$30/MTCO₂ (+\$6.79/MWh) (Source: CARB)
 **No facilities in this state for DNI > 711 W/m²

NLR analyzed select industrial sector plants (based on NAICS codes) representing food & beverage, chemical, and other industries. These analyzed facilities represent about 10% of the US industrial sector. NLR then focused on half of these facilities in high-sunlight regions.



$$\frac{LCOH}{LCOH_{NG}} < 1.0 \rightarrow \text{Cost-saving}$$

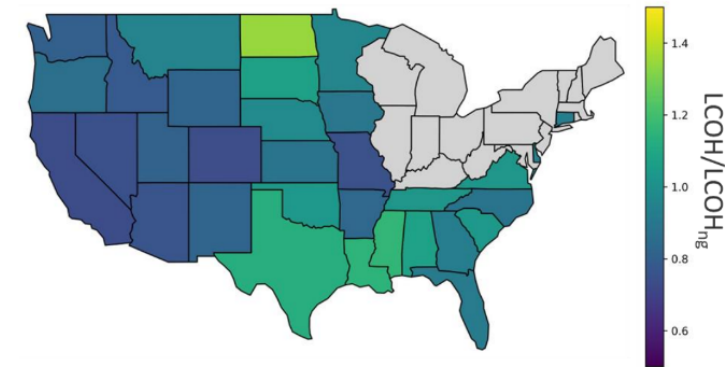
$$\frac{LCOH}{LCOH_{NG}} > 1.0 \rightarrow \text{Not Cost-saving}$$

Cost effective facilities represent 0.51 quads of energy per year within this limited study.

Why hasn't SHIP been deployed more today?

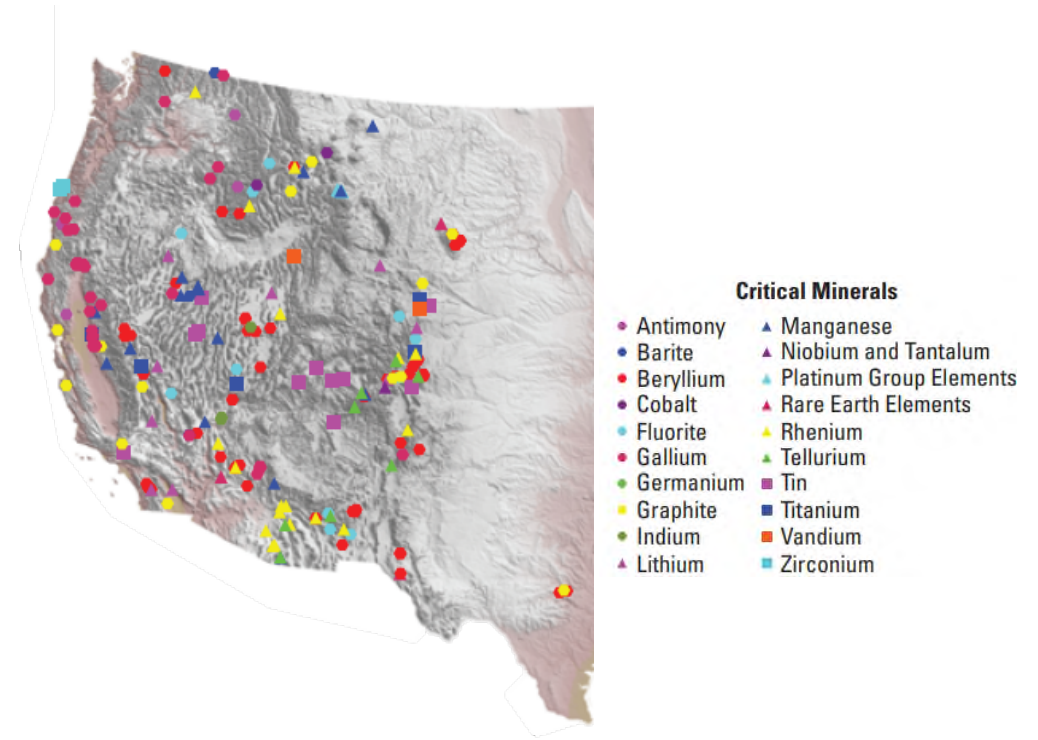
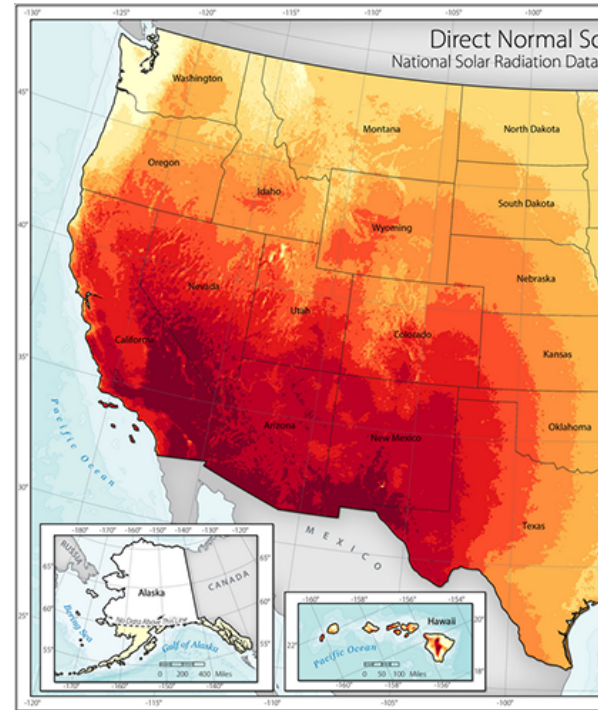
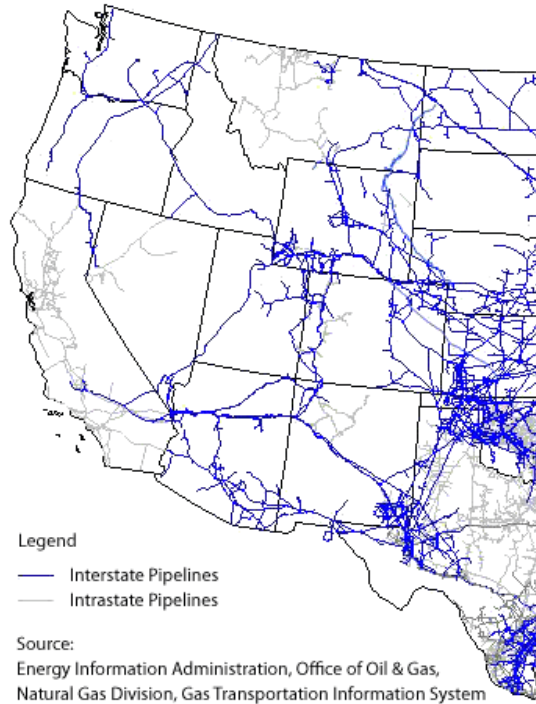
- 1) Lack of user awareness of the technology.
- 2) Lack of domestic manufactures and few qualified project developers.
- 3) Project specific engineering costs that haven't been standardized.

Figure 60. Distribution of LCOH/LCOH_{ng} for CST+TES systems at 25% capacity factor for Task 3 dataset.



Savings with 25% of the energy load displaced by SHIP in select low temperature industries

Many remote areas with critical mineral deposits have high sun and low gas/grid connectivity



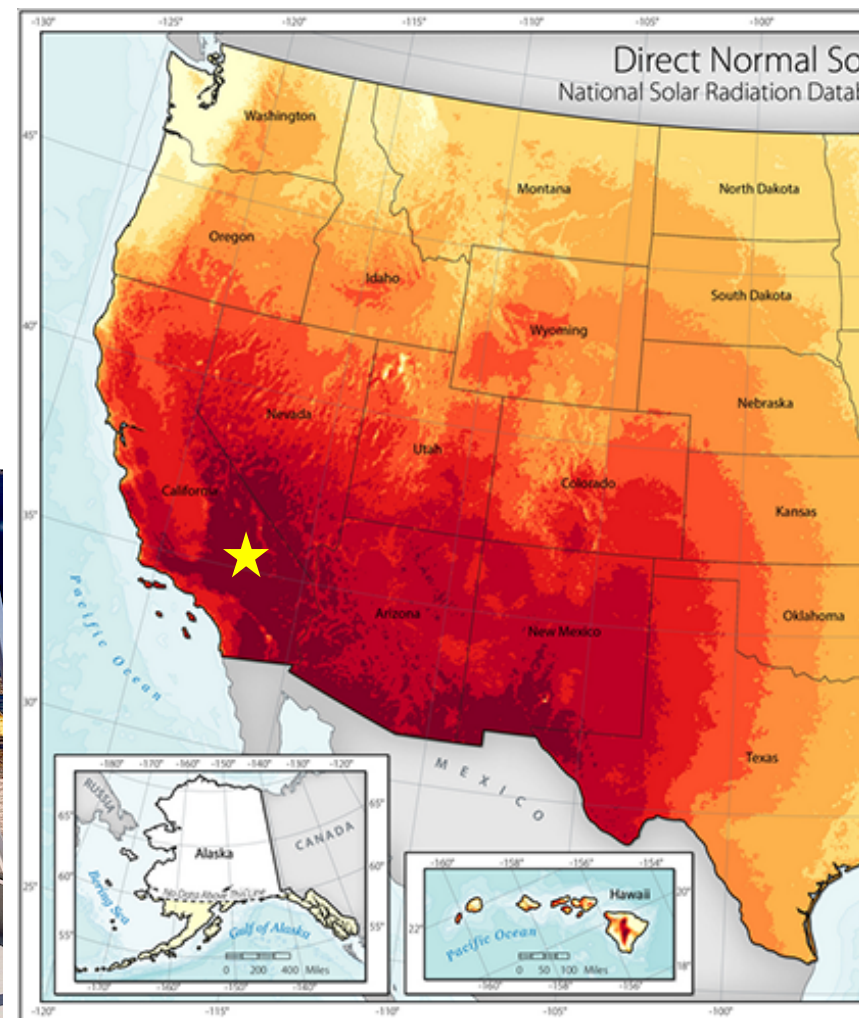
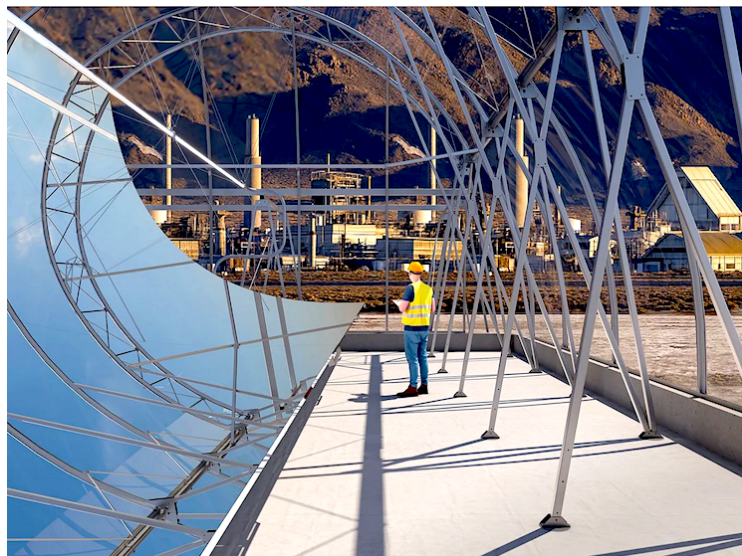
Remote mining: Glasspoint's boron extraction project in CA

750 MW solar-thermal to deliver 250 MW of steam round the clock

- Searles Valley Minerals uses 1.2 million lb/hr of steam via coal burner.
- SHIP retrofit with molten salt will provide 700,000 lb/hr.
- Facility is a second-of-a-kind deployment of Glasspoint's collector technology following a 350 MW facility in Oman for Enhanced Oil Recovery.
- Facility owners anticipate cost savings.

Extracted borax and borates can be used for:

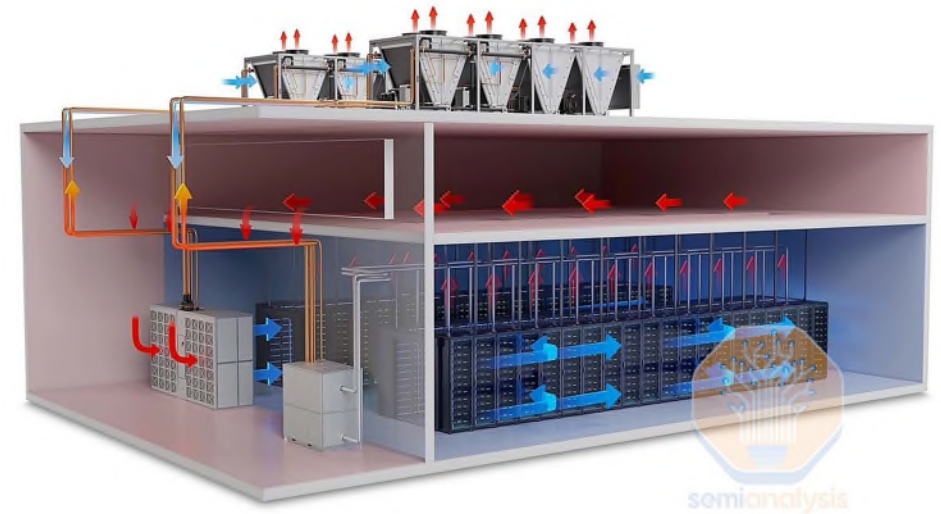
- Neutron shielding for nuclear energy
- Production of permanent magnets and super alloys
- High temperature glass and ceramics
- Oil & gas and geothermal drilling fluids



Cooling is Major Energy Demand by Datacenters

- Nearly all energy into the datacenter becomes heat
- 2025 Datacenter average Power Usage Efficiency PUE ~1.4-1.5
 - For 100 MW IT load, need ~150 MW of total electrical grid interconnect (**~30% for cooling**)
- 10's to 100's MWs of low grade (30-40 °C) heat needs to be removed at each datacenter
 - **Low temperatures means few useful offtake solutions** (district heating needs to be nearby)
 - **High water consumption** - Often need water (evaporative chillers) depending on outdoor temps
- **Offloading datacenter cooling to SHIP cooling can create new IT capacity from existing assets.** Gas turbine supply chain bottleneck >5 years for time to delivery

$$PUE = \frac{IT\ Load + Non\ IT\ Load}{IT\ Load}$$



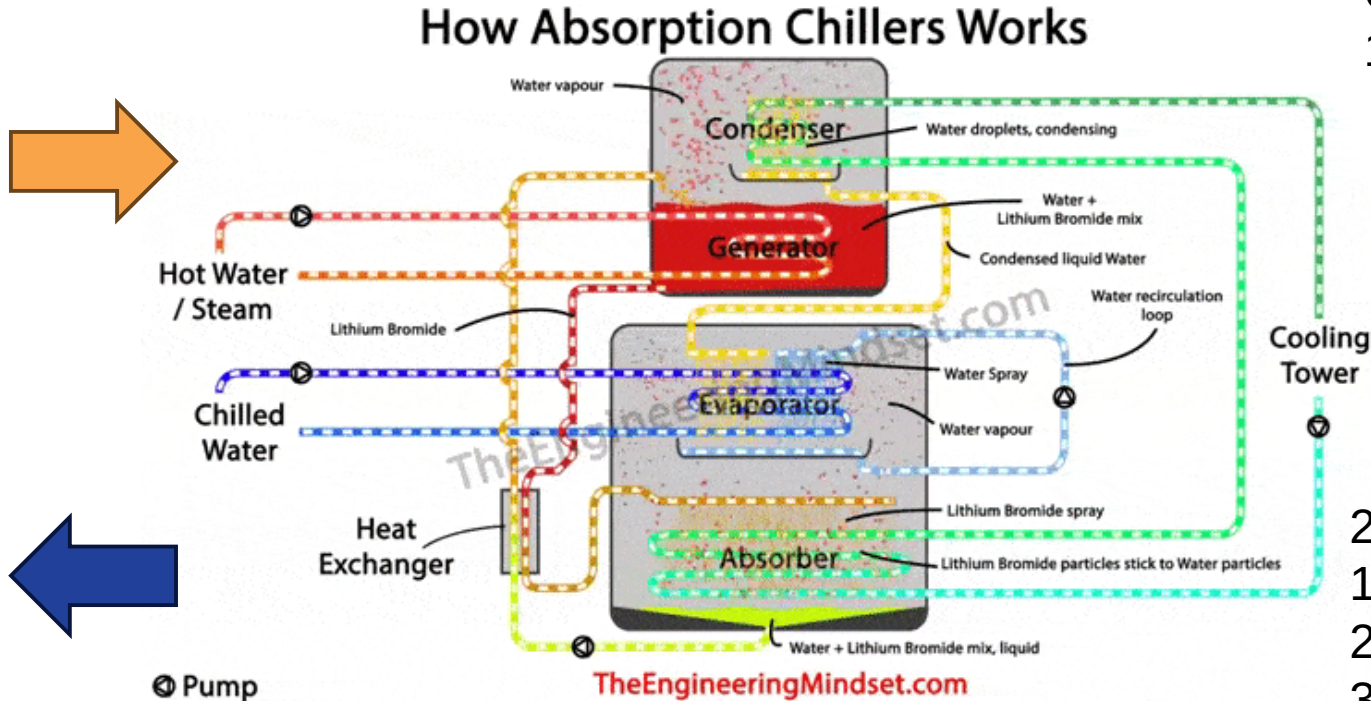
SHIP cooling data centers

Solar Heat → Absorption Refrigeration Cycle → Cooling



Solar Heat for Cooling

Chilled water to cool data centers



Commercially available 10-100 MW scale



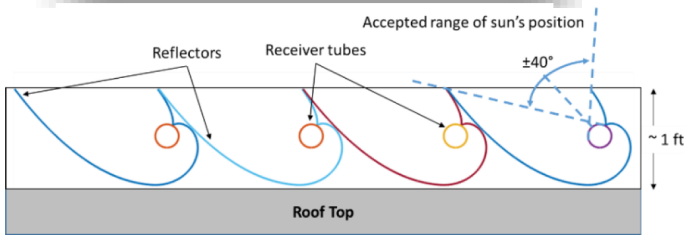
200 °C Solar heat unlocks:

- 1) Dry cooling
- 2) Smaller HX
- 3) Higher COP
- 4) More robust operation envelope
- 5) Decreased grid Impact

Solar Desal Prize & NOFO conclusions

Sunny regions of the US overlap with critical water scarcity regions. Additionally, a key challenge of the oil and gas industry in the Permian Basin is disposing or treating produced water.

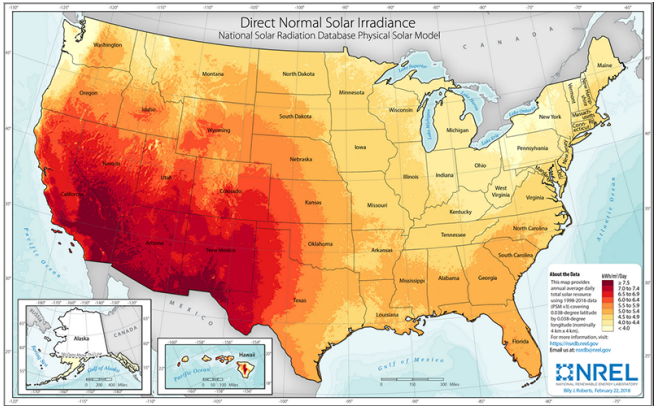
Radipulse's non-tracking collector



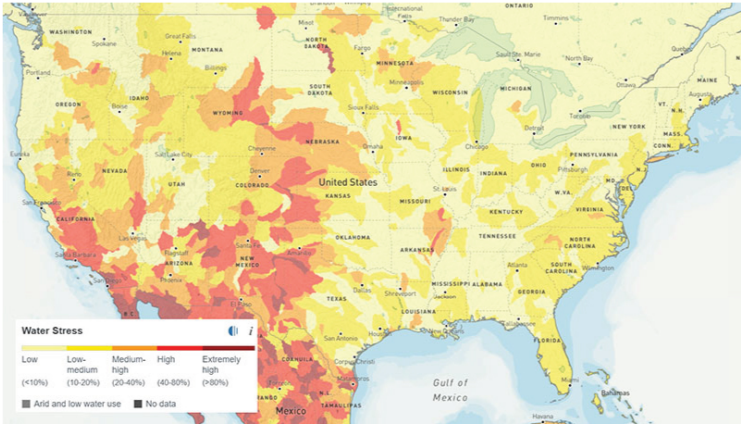
SolMem's integrated multi effect membrane distillation



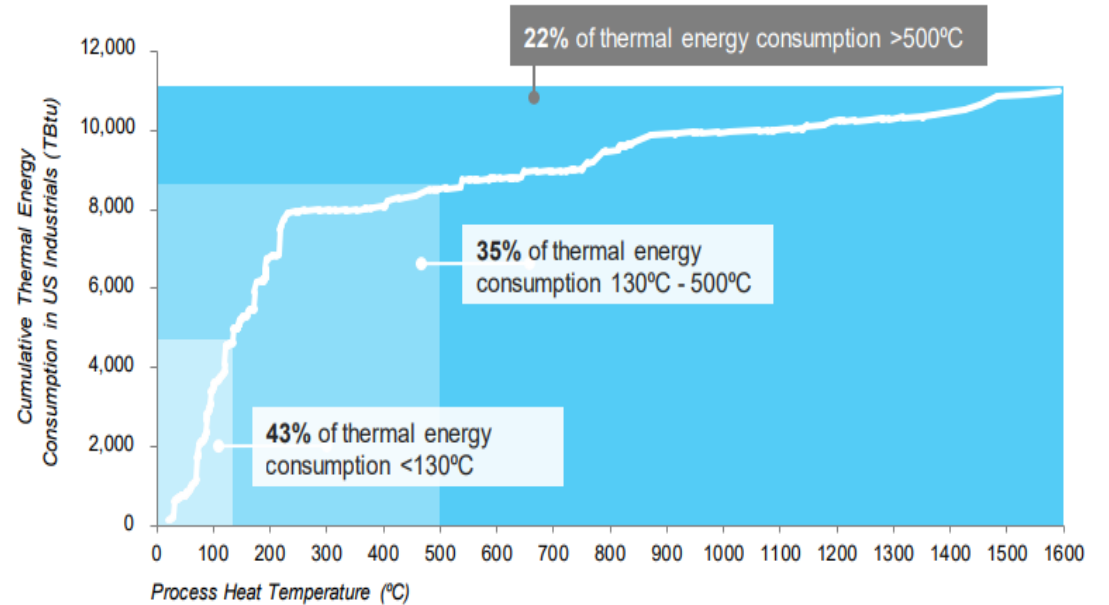
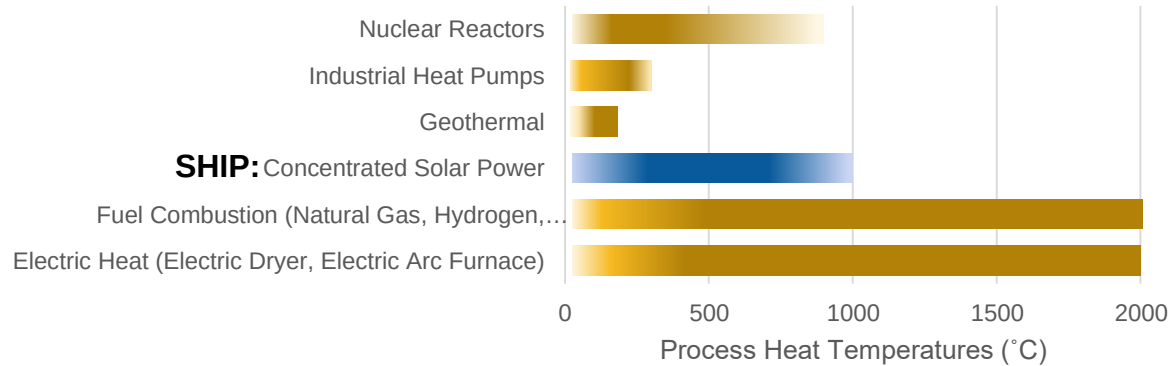
The final contest of the Solar Desalination Prize will result in novel solar collectors and novel thermal desalination processes piloted at water treatment sites. These technologies can enable zero liquid discharge, removing the need for brine management outside the facility. The technologies shown here will be demonstrated at two sites in TX. Reverse osmosis is inadequate for very high salinity brines- necessitating new thermal processes. **The industry partners from O&G sector report cost savings versus alternative options for handling produced water.**



U.S. Water Stress Map



Value proposition

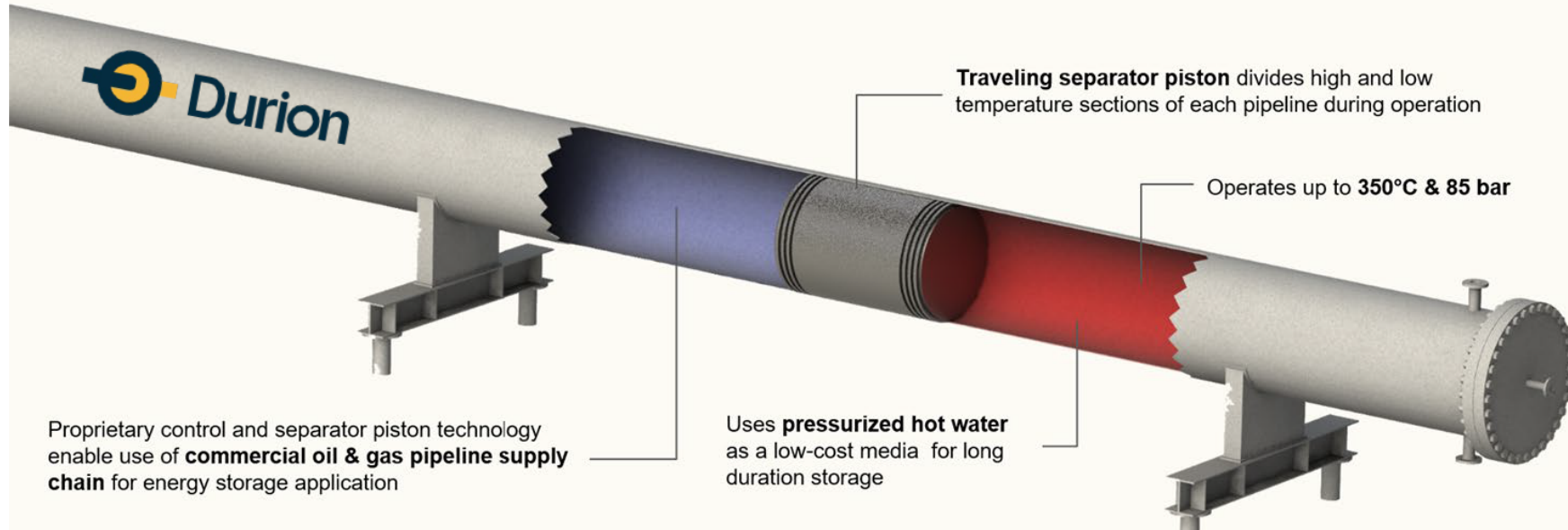


- SHIP can provide heat for industrial needs for temperatures **> 1000 °C**.
- Thermal energy storage (TES) can provide round-the-clock or **dispatchable heat** delivery.
- SHIP can be directly **competitive** with the lowest cost heat sources in some markets.
- SHIP may be the best option in some **remote markets** where fuel and electricity sources are not practical.
- SHIP can help **diversify** the energy mix and provide a hedge against fluctuations in fuel price.
- **Hybridization** with combustible fuel is a near-term opportunity to lower energy costs at existing facilities and seed a domestic supply chain and expertise.

IESO TES Technology Development

Durion: “Ultra Low Cost Long Duration Storage”

- Specifically designed to use affordable and available oil and gas supply chain components
- Five patents already granted, covering our storage and power generation systems



DOE AWARD 11494 includes:

- Design, installation, and testing of 24/7 thermal storage for cold climate heat application using electric boiler & Flex Load Management utility rates.
- Design of full-scale 24/7 combined heat and power system for SunBelt distributed-scale customer



GEOLOGIC THERMAL ENERGY STORAGE

GeoTES

Firm, dispatchable power from sunlight stored in California's depleted oil reservoirs.

5–8 hr

DAILY DISPATCH

1,000 hr

INTEGRAL STORAGE

Concentrated solar thermal charges a sandstone reservoir; stored heat drives a turbine on demand.

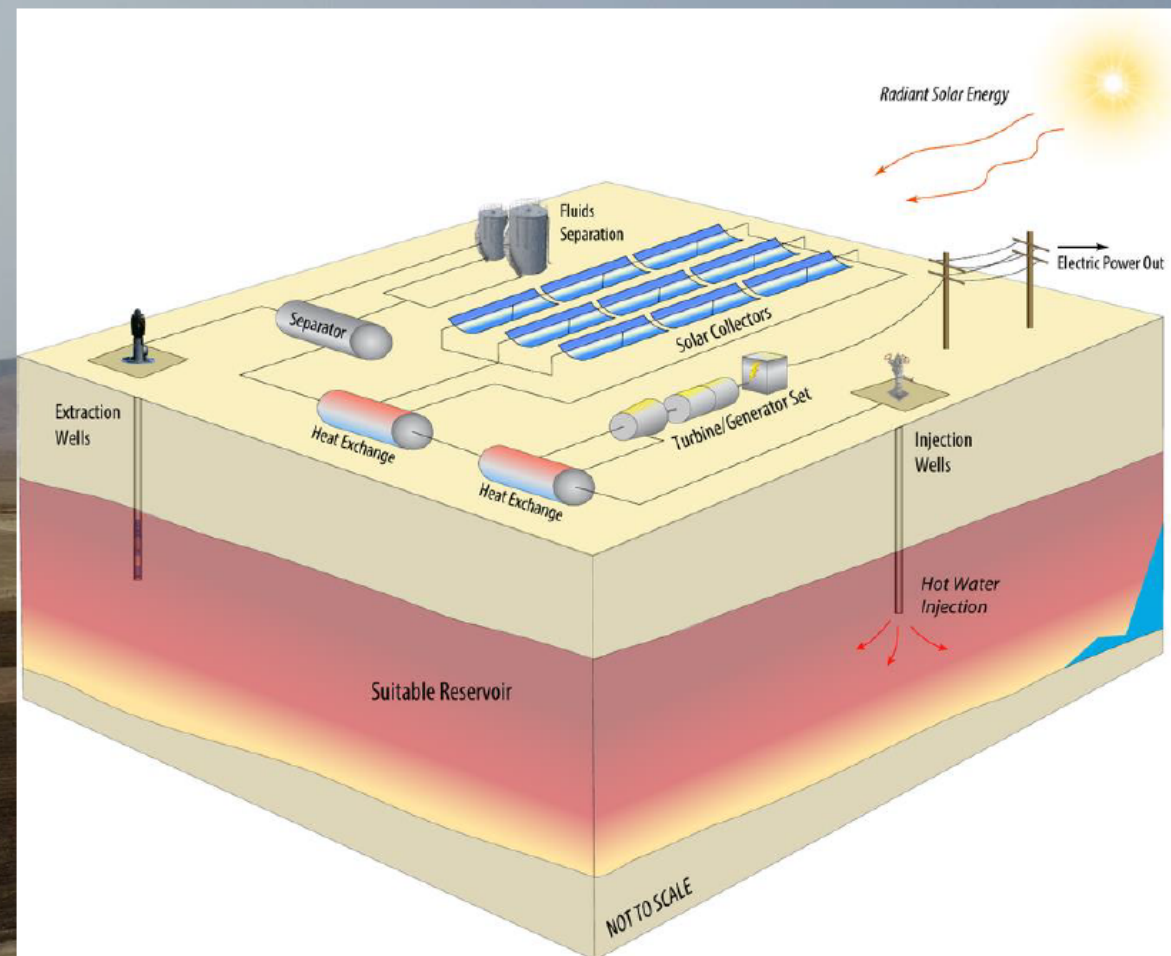
Premier Resource Management, LLC

PARTNERS

National Laboratory of the Rockies (NLR)

U.S. Department of Energy — CMEI · HGEO | Award DE-EE0011495

· ANTELOPE HILLS, KERN COUNTY, CA



Flowing Particles for 600 °C to beyond 1000 °C



Sandia National Laboratories' Gen3 Particle Pilot Plant (G3P3)
775 °C flowing particles TES system. 6 MWh demonstration.

There are over 200 pages of lessons learned from the TESTBED project available to the public

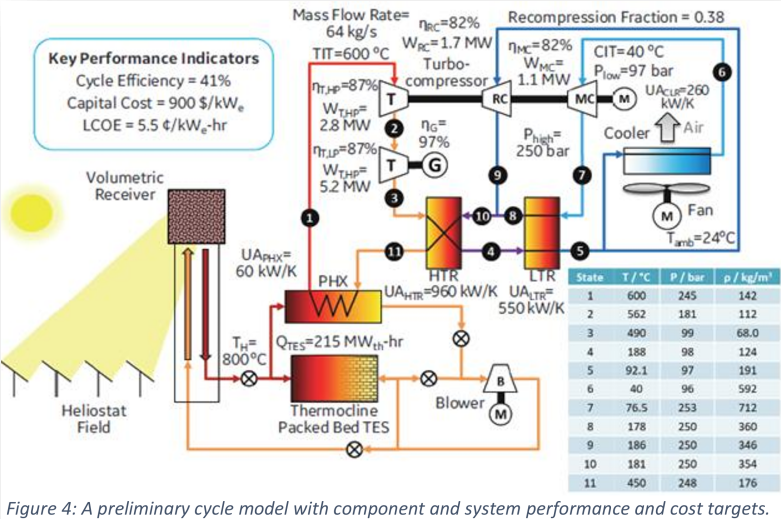


Figure 4: A preliminary cycle model with component and system performance and cost targets.

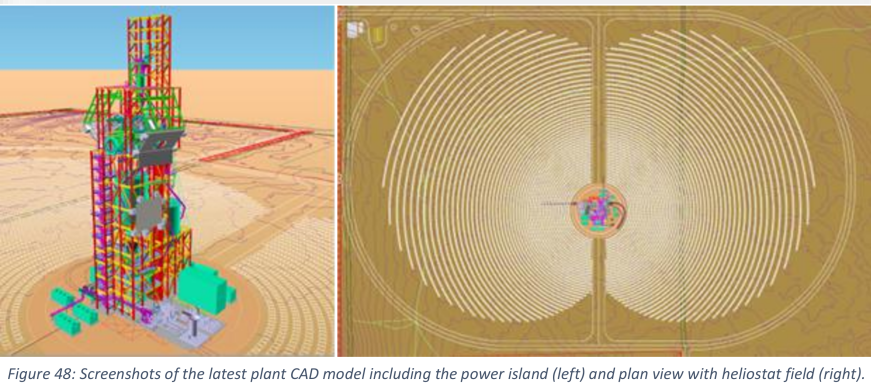


Figure 48: Screenshots of the latest plant CAD model including the power island (left) and plan view with heliostat field (right).

3.3.5 Permitting Lessons Learned

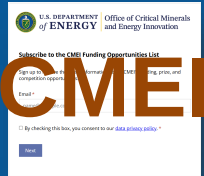
The following permits were required as part of the project approval.

Permit Name	Agency	Status
Land Use permits and CEQA compliance (specifically, a Conditional Use Permit; Zone classification change from A-1 (Limited Agriculture) to A (Exclusive Agriculture); and a request to vacate a public access easement)	Kern County Planning and Natural Resources Department	Land Use permit applications submitted Q3 2021. CEQA NOP published April 2022. As of Q3 2024, first Administrative Draft of the EIR/EA nearly completed and targeted for Q4 2024 Draft EIR/EA publication. Final approval and Board of Supervisor Hearings were tentatively scheduled for Q1 2025.
NEPA Compliance	U.S. Department Energy	Environmental Assessment underway as part of a joint CEQA/NEPA document. See note above and status of required consultations below.
Airspace Consultation from U.S. Department of Defense	U.S. Department of Defense (DoD) Siting Clearinghouse	Completed. Edwards Air Force Base Mission Sustainment Team elected a "No Object" recommendation to the Clearinghouse July 2023.
Obstruction Evaluation / Airport Airspace Analysis	Federal Aviation Administration (FAA)	Completed. Determination of No Hazard issued December 2023.

Snapshot of lessons learned

- Reaffirmed particle advantage over air-based systems for power generation
- Diffusion bonded primary heat exchanger faced manufacturing challenges
- Permitting should be considered from day 1
- Underlined cost uncertainty for first-of-a-kind technologies (costs ballooned from Class-5 to Class-2 estimates)
- Highlighted importance of receiver scalability for commercial systems

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Come talk with us!



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How can DOE best impact technology maturation and commercialization?

ORISE Science and Technology Fellowship

Develop leadership skills in science and technology by designing and implementing national research and development programs aimed at advancing a resilient, integrated, and affordable energy future.

Strategic Areas:

- Advanced solar photovoltaic technologies
- Wind energy technologies
- [Solar heat for industrial processes](#)
- [Thermal energy systems](#)
- Grid integration technologies
- [Distributed energy technologies](#)
- Interconnection innovation
- Permitting and environmental impact reduction
- Cross-cutting analysis and program impact evaluation
- [Energy materials and recycling](#)
- [Manufacturing and technology transfer](#)
- Communications, graphic design, and stakeholder engagement

Apply Here:



Benefits:

- One-year appointment, renewable for a second year
- Competitive stipend and paid leave
- Mentorship from DOE officials
- Travel/professional development allowance
- Local transportation stipend

Application Deadline: **July 31**

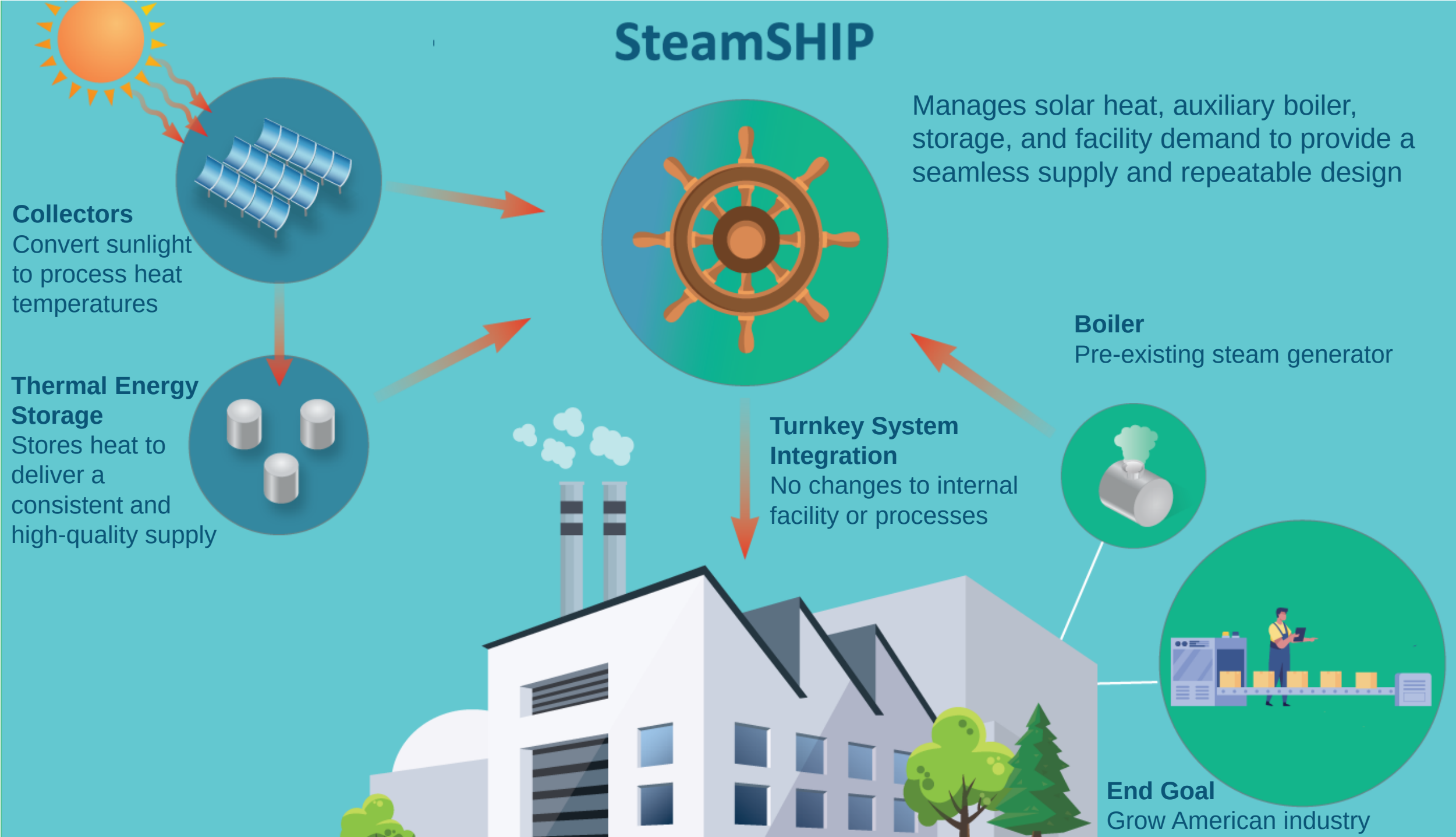
Eligibility:

Direct background in solar, wind, or other energy resources is not required for this opportunity, but strong candidates will have skill sets that transfer directly to the work done at IESO. IESO is interested in candidates with backgrounds including but not limited to physical and natural sciences, social science, engineering, public administration, entrepreneurship, community and sustainability work, and others with bachelor's, master's, or doctoral degrees, as well as established professionals with relevant post-degree experience. Participants must be a U.S. citizen or have Permanent Resident (Green Card) status.

Stakeholder Engagement Key Learnings

- **No one wants to change their key industrial processes**
 - “The plant manager just wants to be left alone. If the plant goes down for a day, they get fired.”
- **Accurate performance models are important to set customer and financier expectation. Limits of laboratory testing.**
 - “large collectors deployed in the field are often not tested because they are difficult to test [impacting the cost of capital]”
 - “At the end of the day, financiers want a predictable annual yield to know if they can make money”
- **Need to convene broad expertise to implement good SHIP systems**
 - “Engineers from oil and gas can do a better job engineering a steam system, but these projects don’t typically include them, so you have solar engineers trying to do plant engineering”
 - “It’s crucial to involve local contractors in plant design”
- **Permitting remains challenging because of lack of familiarity**
 - “we’re having to spend months educating AHJs each time because they are unfamiliar with the technology”
- **People are interested but they also don’t know where to start**
 - “lack of information centralization”
 - “DOE could play a role of spreading that knowledge so that people don't have to learn on their own”.

SteamSHIP



Integrating SHIP into American Facilities



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