U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY
SOLAR ENERGY TECHNOLOGIES OFFICE

Industrial Decarbonization: Renewable Process Heating from Concentrating Solar Thermal

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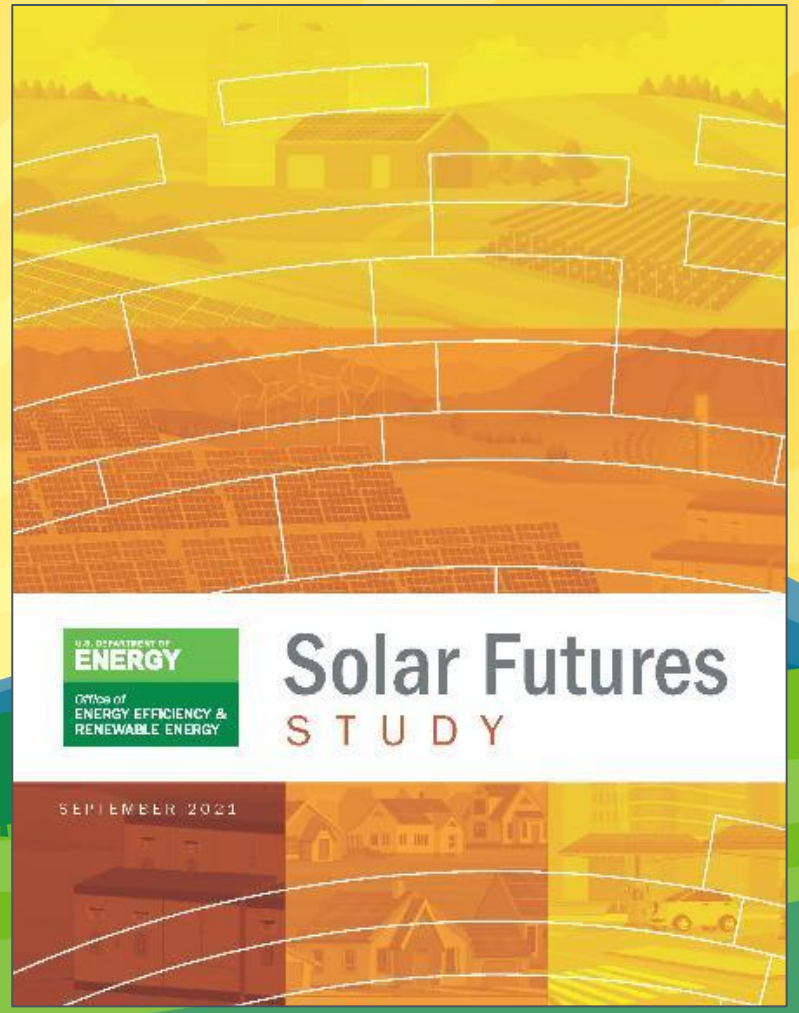
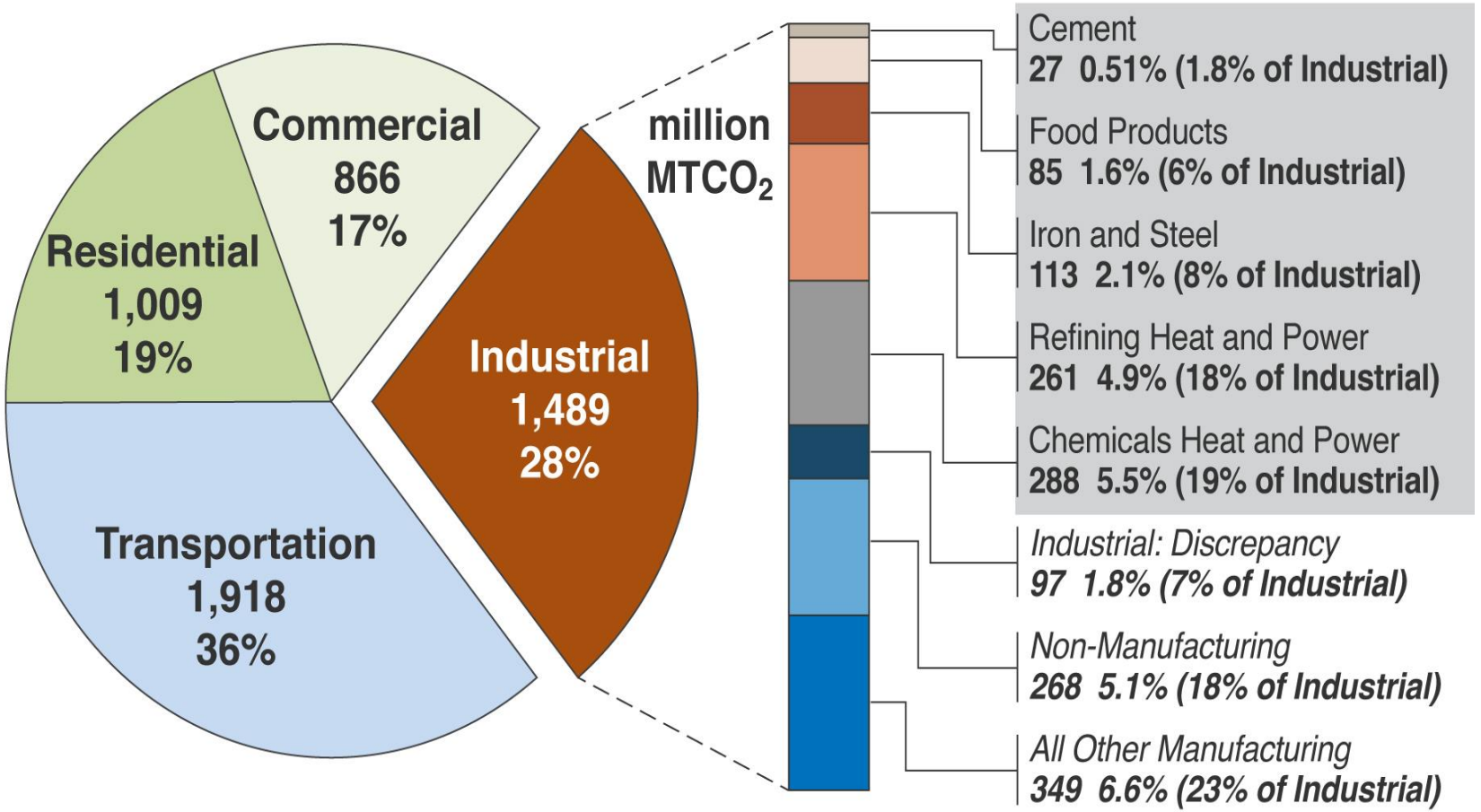
energy.gov/solar-office

Driving Toward Administration Decarbonization Goals

- **Reduce hardware and soft costs** of solar electricity **for all Americans** to enable an affordable carbon-free power sector by 2035.
- Enable inverter-based technologies to provide essential grid services and black start capabilities while demonstrating the **reliable, resilient and secure operation of a 100% clean energy grid**.
- **Accelerate solar deployment and associated job growth** by opening new markets, reducing regulatory barriers, providing workforce training, and growing U.S. manufacturing.
- **Center energy justice** by reducing environmental impacts, removing barriers to equitable solar access, and supporting a diverse and inclusive workforce.
- **Support a decarbonized industrial sector with advanced concentrating solar-thermal technologies and develop affordable renewable fuels produced by solar energy.**

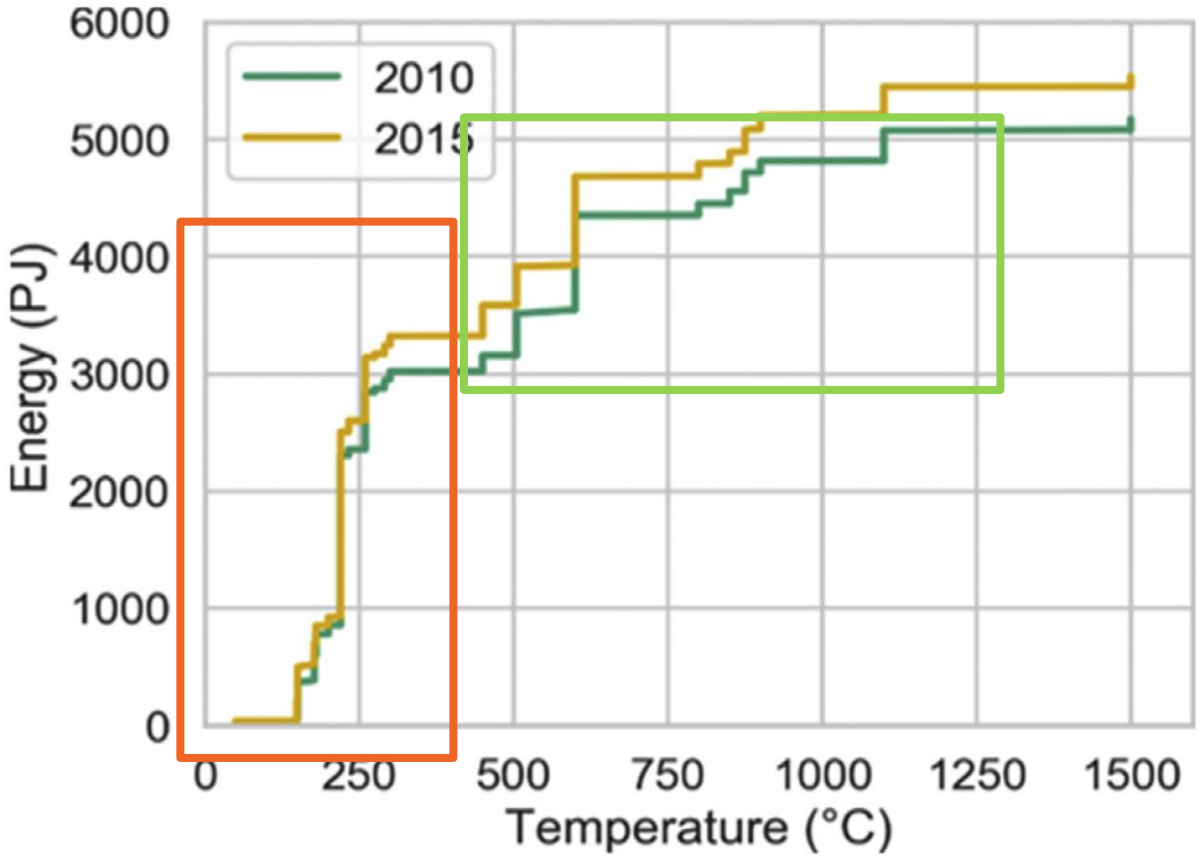


Opportunities for Solar IPH



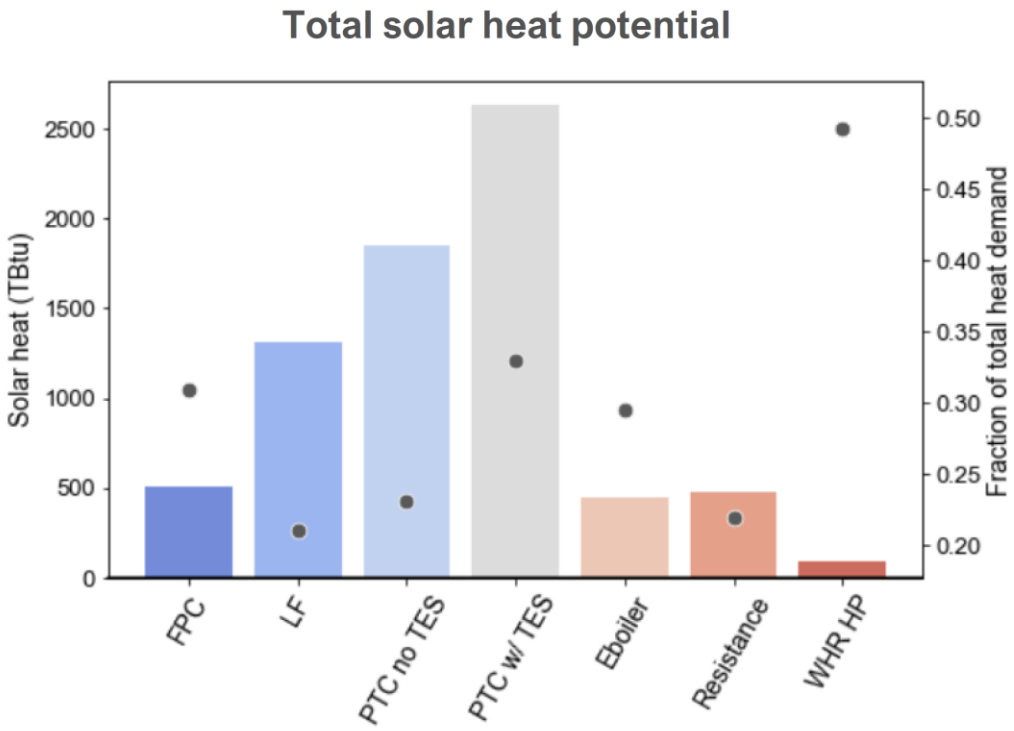
Data source: EIA 2020, United States Energy Information Administration, Annual Energy Outlook 2020 with Projections to 2050

Opportunities for Solar IPH



Process heating energy demand by process temperature for large US industrial facilities

Schoeneberger, et al., **Energy**, *206*, 118083

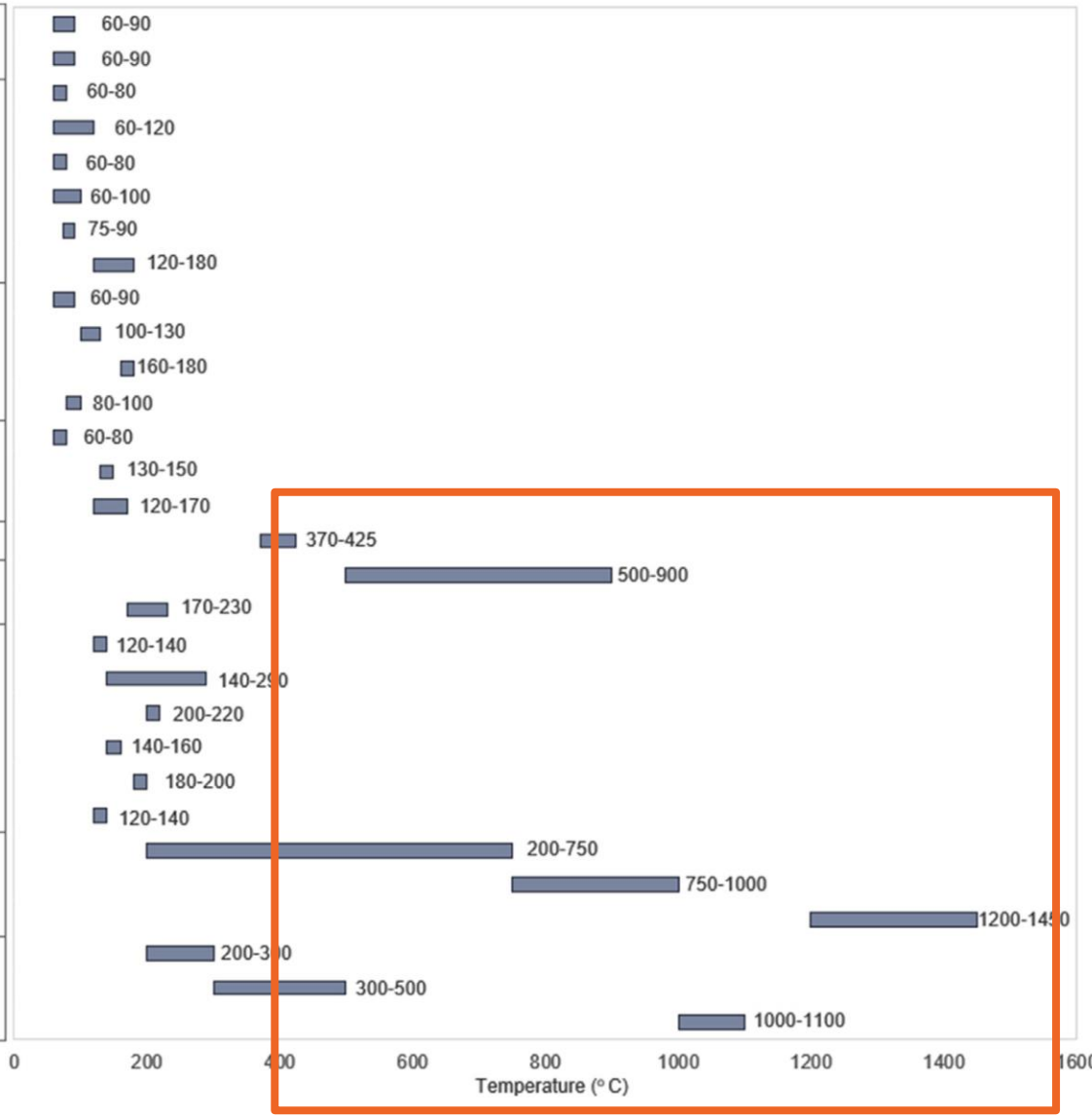


Existing CSP technologies can provide a significant fraction of heat for low temperature (< 400 °C) processes

McMillan, et al., **NREL/PR-6A20-79083**

Opportunities for Solar IPH

Cross-cutting	Water preheating
	Washing
Food and Beverages	Pasteurization
	Sterilization
	Concentration
	Cooking
	Blanching
	Drying
Textiles	Bleaching/dyeing
	Drying
	Fixing
	Pressing
Paper and Wood Products	Cooking/drying
	Bleaching
	Pulp preparation
Petroleum Refining	Distillation
Chemicals	Steam reforming
	Drying, distillation
Plastics	Preparation
	Distillation
	Separation
	Extension
	Drying
	Blending
Nonmetallic Minerals	Preheating
	Calcination (dry)
	Sintering
Primary Metals	Precipitation
	Annealing
	Reduction (ore)



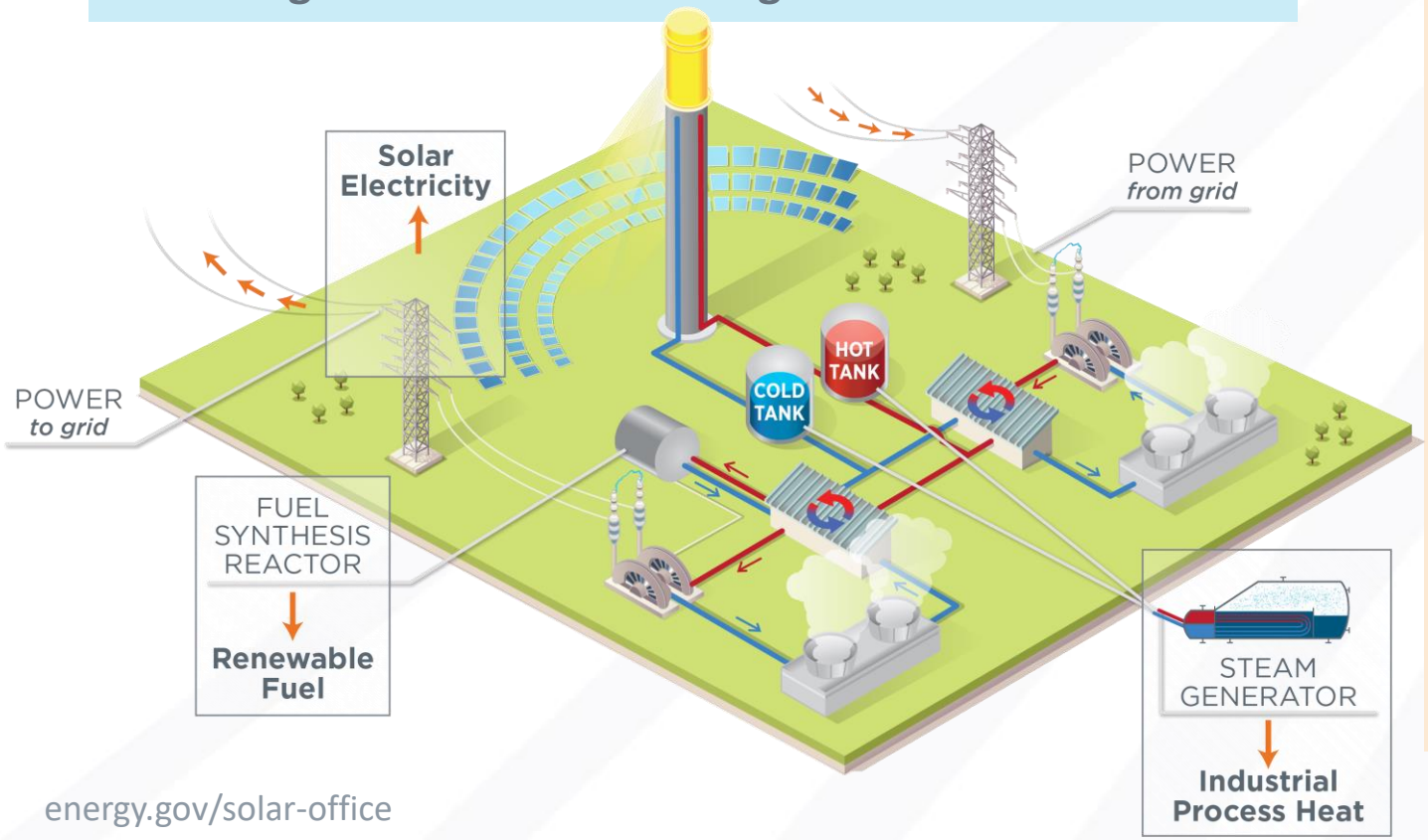
Focus of this workshop: Identifying opportunities for concentrating solar thermal heating of high-temperature industrial processes

Schoeneberger, et al., **Energy**, *206*, 118083

Solar Thermal for Decarbonization of Industrial Process Heat

Thermally-Driven Industrial Processes:

- Desalination
- Enhanced Oil Recovery
- Agriculture and Food Processing
- **Fuel and Chemicals Production**
- **Mining and Metals Processing**



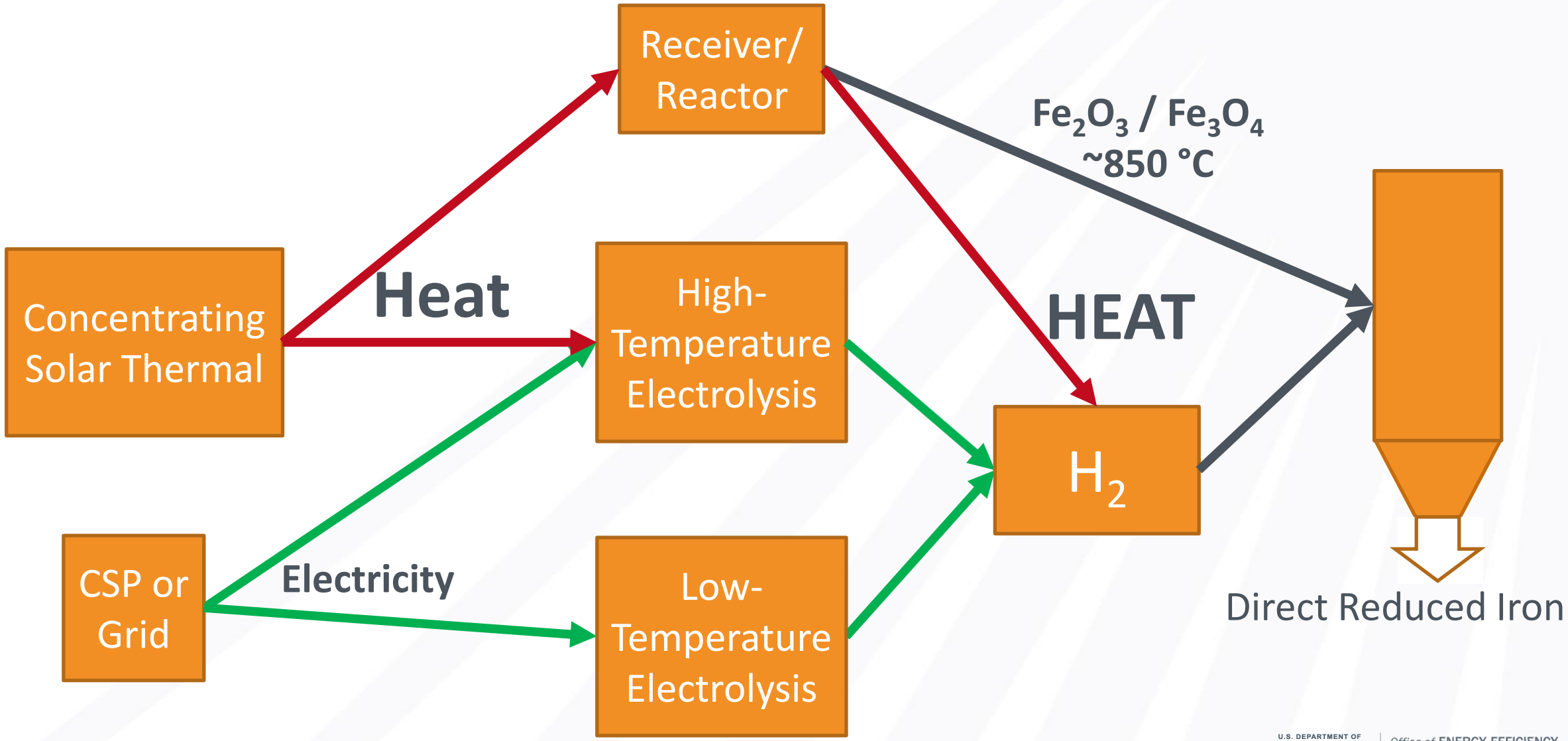
Priority Research Areas:

- Focus on high-impact industries such as steel, cement, ammonia, chemicals and fuels
- Improve the **thermal efficiency** of solar-thermal-coupled processes
- Applicants focus on reactor design, heat input to reactors, catalysts, recuperators to enable novel solar thermochemical processes

SETO Goals by 2025:

- Define system concepts and key components for solar process heat for carbon-emissions-intensive, high-heat-demand industries
- Define system concepts and key components for producing fuels from CSP

Example: Iron/Steel Production



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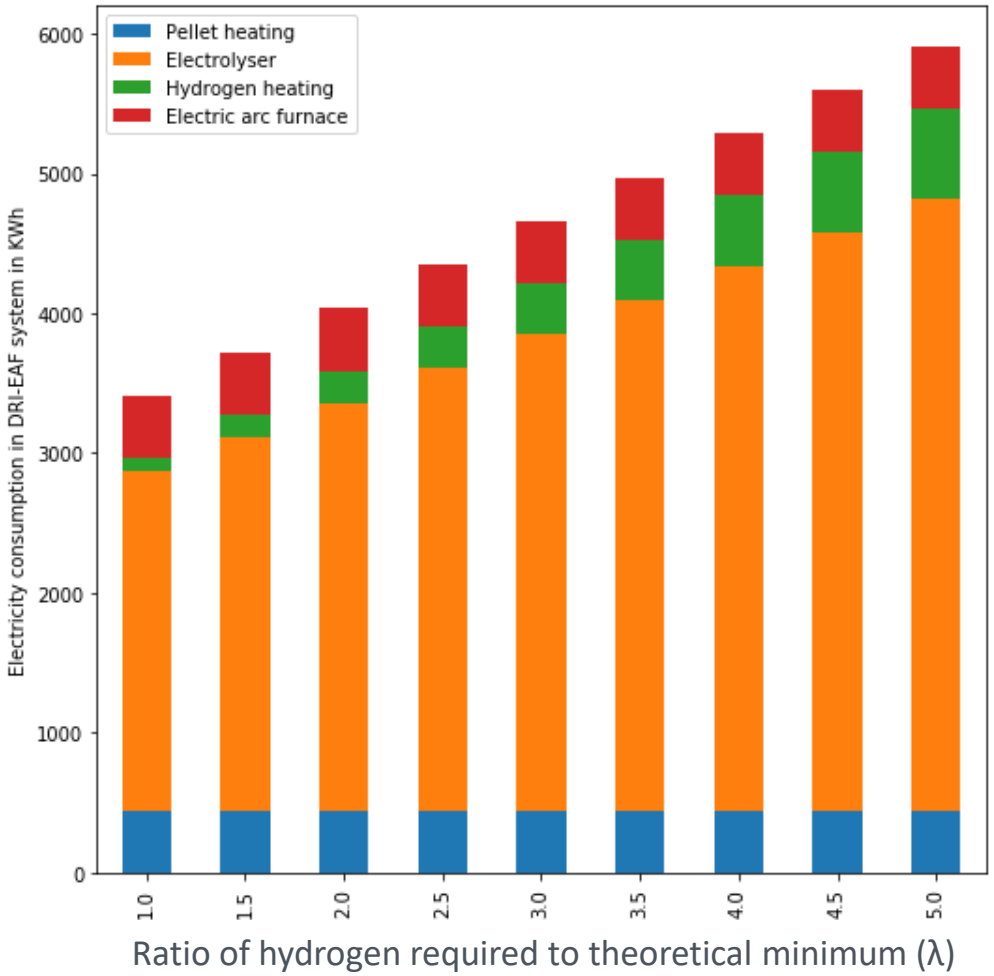


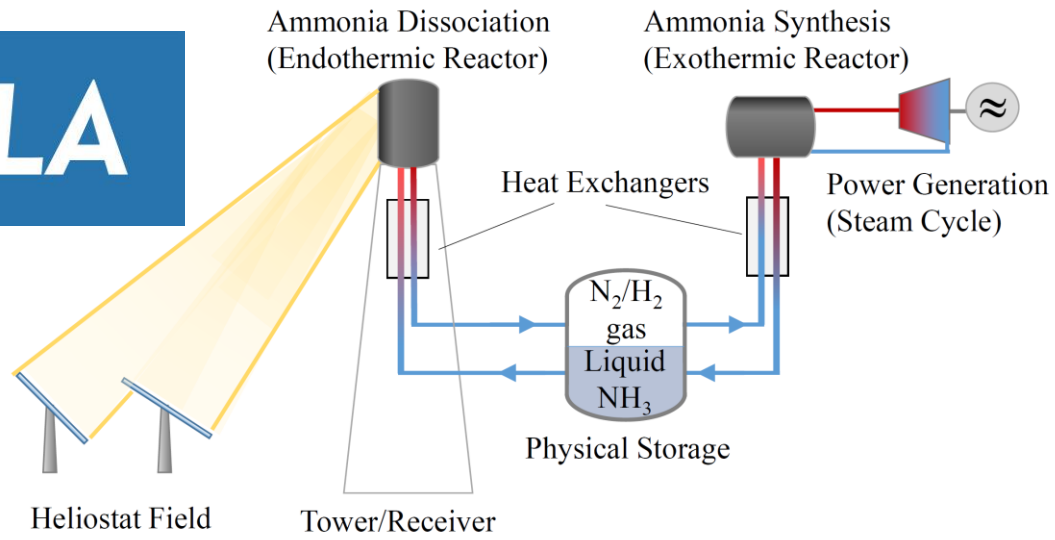
Potential Solar Thermal Contribution to production of Direct Reduced Iron with H_2:

- 20-30% of energy is needed for heating iron ore pellets and hydrogen
- High-temperature electrolysis (e.g. with solid oxide electrolysis cells), could potentially reduce electricity consumption ~20%

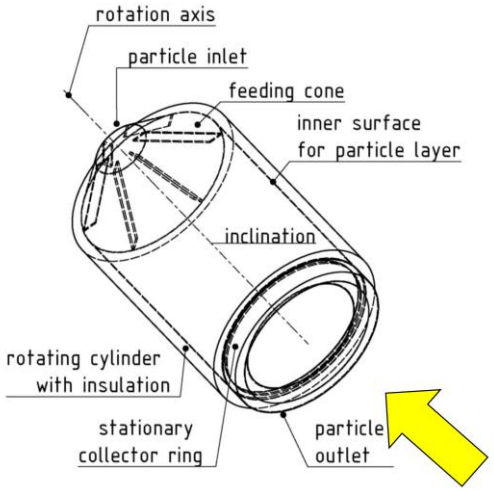
Bhaskar, et al. *Energies* **2020**, *13*, 758

Examples: Cement, Ammonia, Fuels

UCLA



Lavine, et al. https://www.osti.gov/biblio/1425351

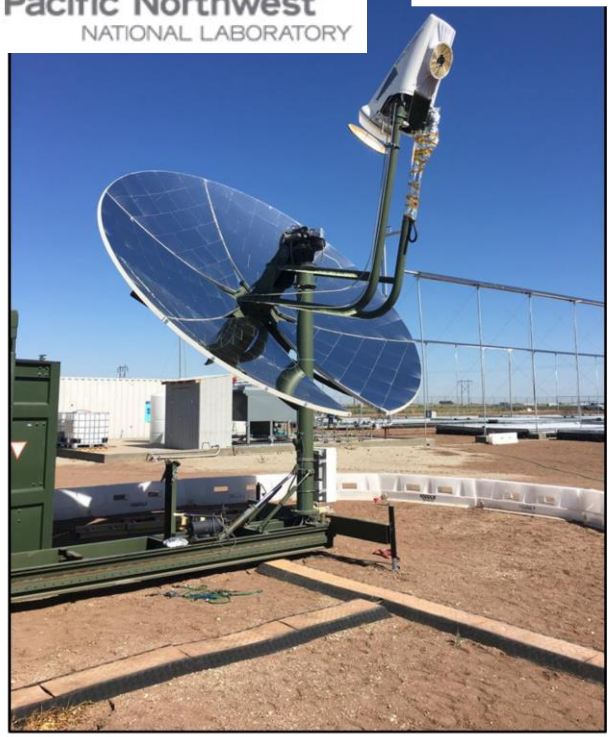


Sandia National Laboratories

DLR

Pacific Northwest NATIONAL LABORATORY

SoCalGas



$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$

Wegeng, et al.
https://www.osti.gov/biblio/1514768

QUESTIONS?

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