Solar for Industrial Process Heat

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Overview

- The industrial sector accounts for roughly 1/3rd of all U.S. primary energy use (32 Quads).
  - Industrial Process Heat (IPH) accounts for roughly 7.5 Quads.
  - IPH for manufacturing is > 90% through fuels like NG
- What role can solar technologies (CSP and PV) play in meeting a wide range of IPH end uses in the U.S.?
  - Fuel saving
  - Broader transformation

(Data from EIA 2017; U.S. DOE 2014)
Industrial Processes Require a Wide-Range of Temps

- Industrial processes range from those requiring hot water at 70°C to those melting steel scrap at 1,800°C.
- Select industrial players could be prime targets for technology adoption and demonstration.

New Solar IPH markets could open up as:
- the cost of solar technologies (CSP and PV) declines
- the cost of complementary technologies (storage, efficiency, electrification) declines

Solar technologies could meet a broad range of industrial process temperature requirements.

<table>
<thead>
<tr>
<th>Solar Technologies</th>
<th>Temp Range</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal flat plate, Non-tracking compound, Solar pond, PV + heat pump or microwave</td>
<td>&lt;80°C</td>
<td>Hot water, Space heating, Drying, Curing</td>
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<tr>
<td>Parabolic trough, Linear Fresnel, PV + infrared</td>
<td>&lt;550°C (depending on HTF)</td>
<td>Drying and curing Steam for IPH</td>
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<tr>
<td>Heliostat/central receiver</td>
<td>&gt;550°C</td>
<td>Steam for IPH, Lime calcining</td>
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<tr>
<td>PV + Induction</td>
<td>&lt;1,100°C</td>
<td>Heat treating</td>
</tr>
<tr>
<td>PV + Resistance</td>
<td>&lt;1,700°C + (material dependent)</td>
<td>Steam for IPH Glass melting</td>
</tr>
<tr>
<td>PV + Electric arc</td>
<td>&lt;4,000°C</td>
<td>Metal melting</td>
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• Process parity is the point at which the levelized cost of heat (LCOH) from solar is equivalent to the levelized cost of heat from other sources, e.g. fuel

• Estimating process parity requires expanding datasets and carrying out detailed process level modeling.
Where Potential Meets Demand

- Locations of food processing across California with solar-thermal energy potential
- Use the NREL System Advisor Model (SAM) and other analysis tools, to model systems (e.g. solar IPH) and determine locations with good potential


- Central Valley provides good resource and industry proximity
- Industries such as Fruit and Veg clustered together in good thermal potential areas and with nearby available land
Example: Energy Profile of Brewing in the U.S.

- **Beverage sector**
  - ~43 TBtu for boiler and process heat
  - ~84% natural gas

- **Thermal demands by temperature**
  - Washing (70°C)
  - Cooking (100°C)
  - Mashing (70°C)
  - Brewing (100°C)
  - Drying (100°C)
  - Pasteurizing (65°C)


Characteristics of Brewery Process Heat Demand

- Brewery temperature requirements are well-matched to solar technologies
  - Solar thermal is already being used in the U.S., Germany and other countries
- Breweries have standard production processes (e.g. mash boiling), but are operated differently and at range of scales
- Opportunities also exist for waste heat recovery (e.g., from boiler flue gases and steam re-condensation), but timing of hot and cold streams needs matching
- Thermal energy storage (TES) is critical for reducing heat demand

Brewing with Solar Thermal Preheating

Conclusions

• With the emergence of lower-cost solar technologies, it is important to develop data and analysis that enable decision makers and analysts to explore how IPH might shift toward renewable sources over the coming decades.
  • Industrial process heat represents a significant potential market for solar, roughly 7.5 Quads in the U.S.
  • A mix of solar technologies (CSP and PV) could be used to meet a broad range of industrial process temperature requirements.

• Two potential Solar IPH strategies:
  1. As an add-on to existing processes to provide fuel savings
  2. As part of a broader process modification strategy to drastically reduce fuel use (linked with storage, efficiency, electrification, etc.)