Objective

- Design and construct a solar steam generator capable of at least 1 kW steam output.
- Propose “scaled up” designs for 100 & 500 BHP (1 & 5 MW) solar boiler for use in peppermint oil extraction.

Background

- The most common extraction process used by the Oregon mint industry uses steam distillation.
- Current methods of producing the steam are to use diesel or coal fired boilers with high emissions and fuel consumption.

Design

- Parabolic trough solar concentrator:
  - 4'x8' aperture.
  - 1” copper pipe coated with a selective surface paint.
  - Reflective metalized polyester

- Generates steam at 15 psig within 4 minutes.

Energy Balance

\[ \dot{m}(C_p \Delta T + \Delta h_{vap}) = I_o A_d \rho \eta \alpha - A_p h(T_p - T_a) - A_p \sigma \varepsilon (T_p^4 - T_{sky}^4) \]

- 140 °C maximum temperature achieved.
- 52% Estimated efficiency.

Scale Up Parameters

<table>
<thead>
<tr>
<th>100 BPH System</th>
<th>500 BHP System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture Area [ft²]</td>
<td>21,500</td>
</tr>
<tr>
<td>Estimated Land Use [acres]</td>
<td>1.5</td>
</tr>
<tr>
<td>Fuel Displacement [gal/h]</td>
<td>43</td>
</tr>
<tr>
<td>CO₂ Emissions Displaced [lb/h]</td>
<td>963</td>
</tr>
</tbody>
</table>

Future Work

- Modify prototype for continuous flow.
- Investigate direct steam generation versus heat transfer fluid.
- Develop an automated tracking system.

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References