ET Summit 2021

Presented by

EMERGING TECHNOLOGIES COORDINATING COUNCIL

Solar Steam for Deep Decarbonization of Almond Processing

50% Reduction of Carbon Dioxide

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Sunvapor Background

- Technology and project developer at the Food-Water-Energy Nexus
- DOE Awards for solar steam, energy storage, and desalination technologies
- High-performance solar collector manufacturing
- Engineering, Procurement, and Construction Management

Almond Production at California Custom Processing

Problem statement

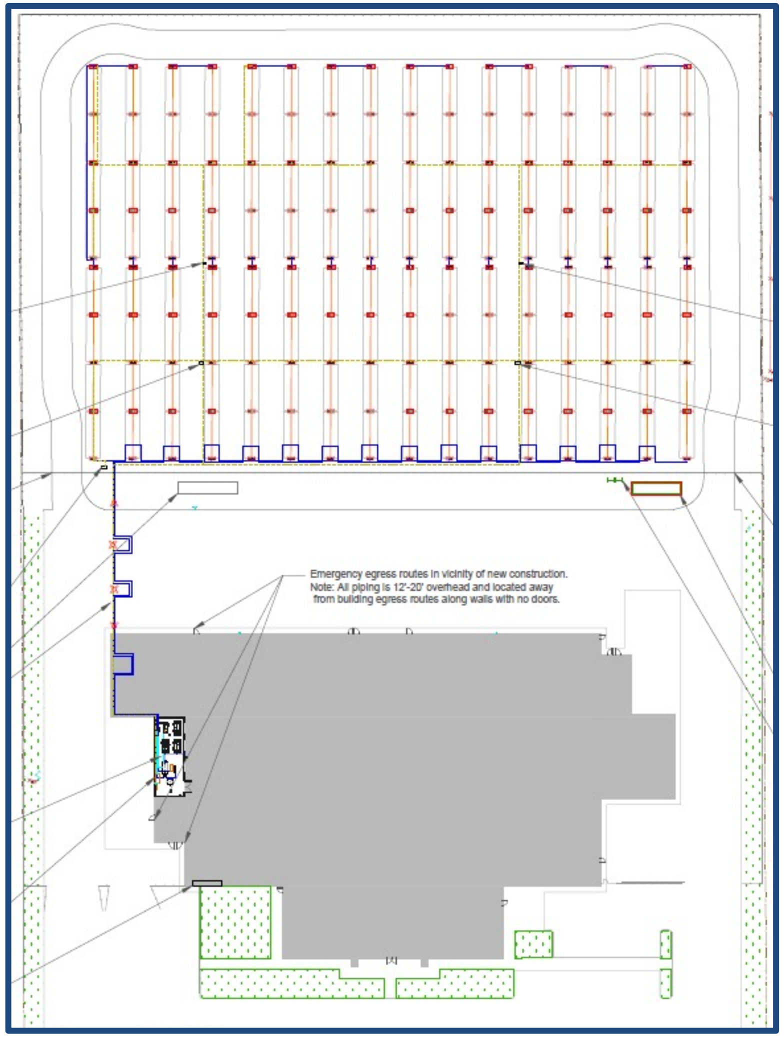
- CCP uses steam for pasteurizing and blanching almonds
- Need for additional steam capacity during the daytime
- Saturated steam at 100 psig/338°F [7 barg/170°C].
  - *Minimum steam conditions for food processing and biofuels*
- Reduce GHG emissions

Why solar thermal steam?

- Electric boiler? PV requires 4X land
- State-of-the-art vapor compression heat pumps cannot even reach 150°C*
- *Only a solar thermal boiler can offset 50% of gas usage within the available land with no emissions* (3.5 acres)

* Arpagaus *et al*, "High Temperature Heat Pumps: Market Overview, State of the Art, Research Status, Refrigerants, and Application Potentials", International Refrigeration and Air Conditioning Conference, 2018

Solar Boiler Overview



Process design

- Eight parallel loops of four SPTC-3000 arrays each
- Solar field delivers heat to Unfired Steam Generator at 230°C with >70% thermal efficiency
- Pressurized water HTF for fire and food safety
- 230 BHP USG has priority over 3 X 50 BHP natural gas boilers

Solar field

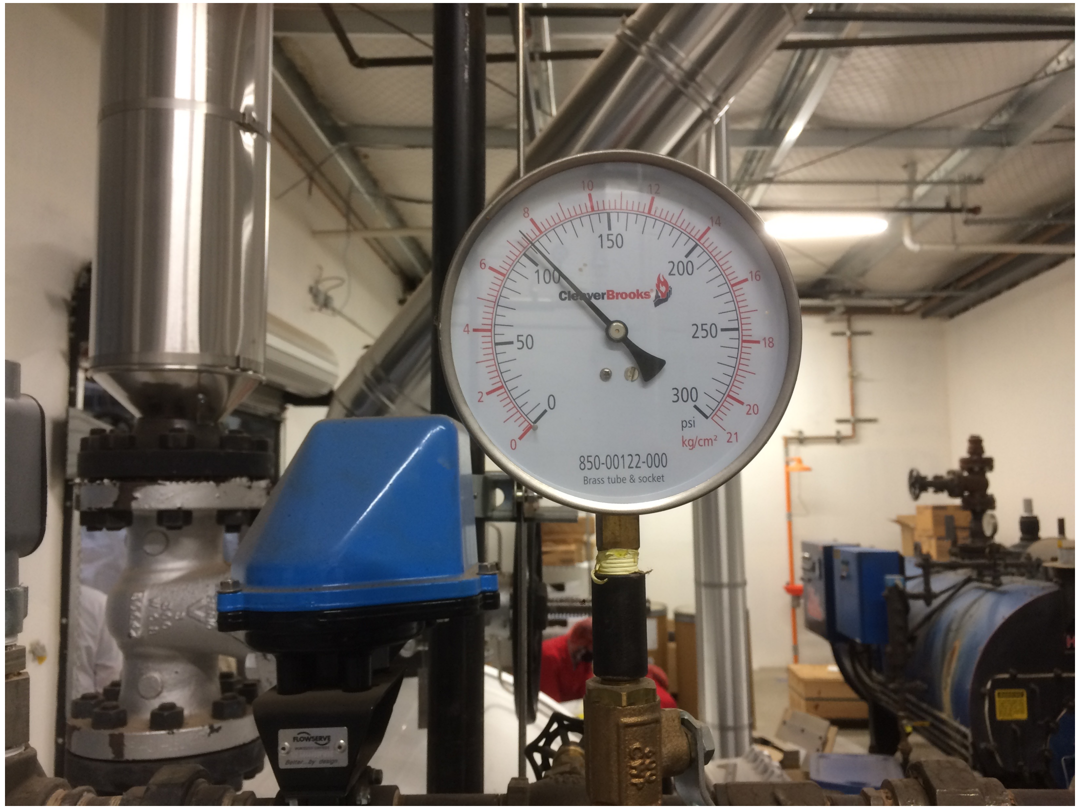
4 Arrays in a loop

4 Modules in each array

Balance of Plant

230 BHP USG and pump

3 X 50 BHP gas-fired boilers



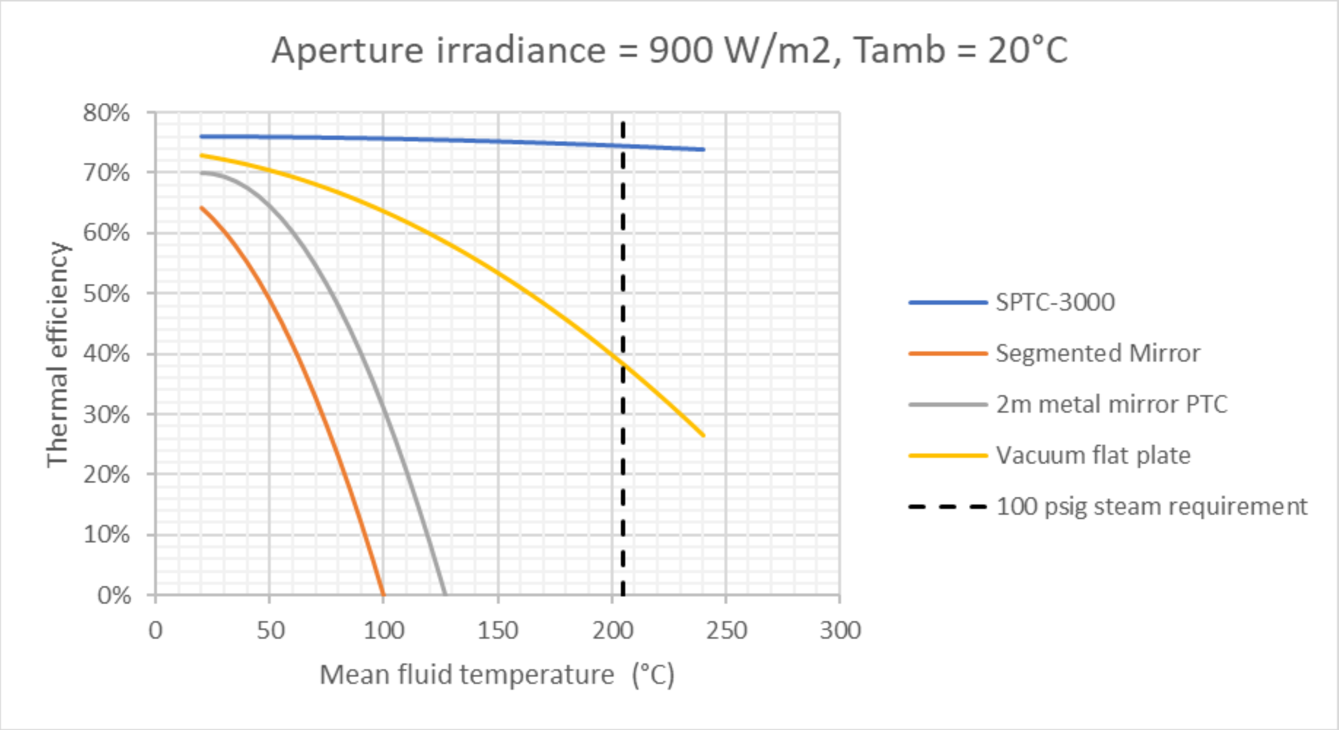
Collector Performance

ISO-9806 Efficiency Equation

$$\eta_{th} = \eta_{opt}\,K - c_1 \frac{\Delta T}{G} - c_2 \frac{\Delta T^2}{G}$$

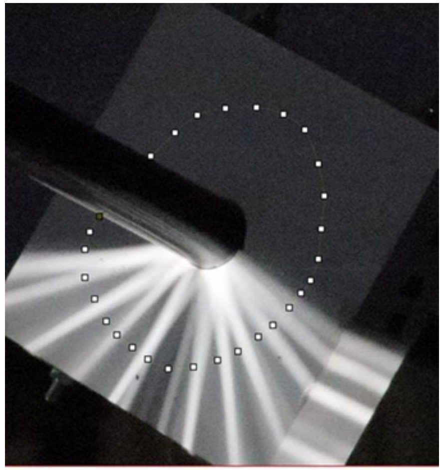
$$\eta_{opt} = \{\rho_{mirror}\,\tau_{glass}\,\alpha_{tube}\}\,Intercept\ Factor$$

Comparison with collectors in the market

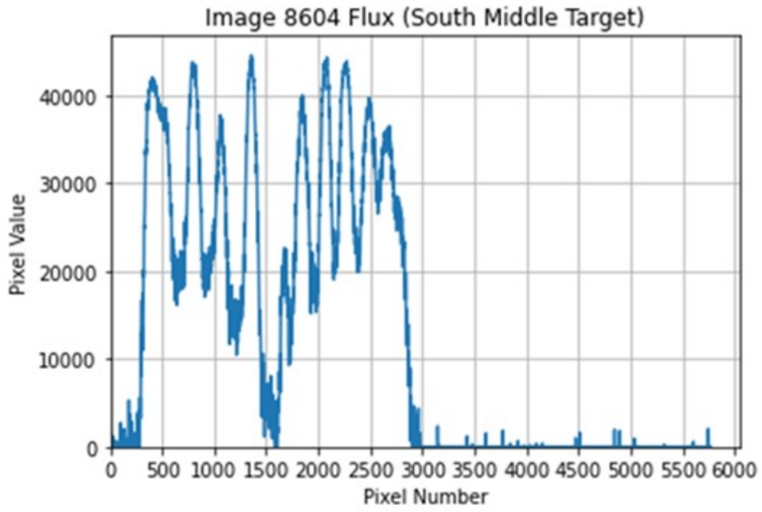


Optical Testing

Intercept factor from targets



Example Result



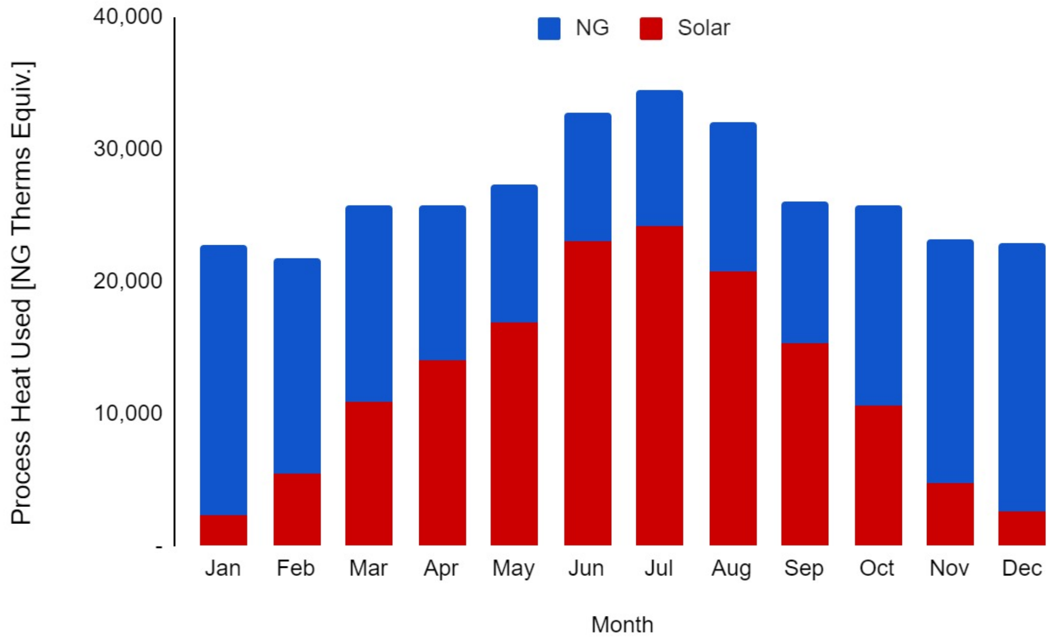
100% intercept factor

Delivered energy modeling

Model inputs

- P90 Solar Resource
- Collector characteristics
- 10% Soiling loss
- Piping heat losses
- Demand response

Results



~ 150,000 therms, 800 MT CO_2 avoided

Measurement and Verification

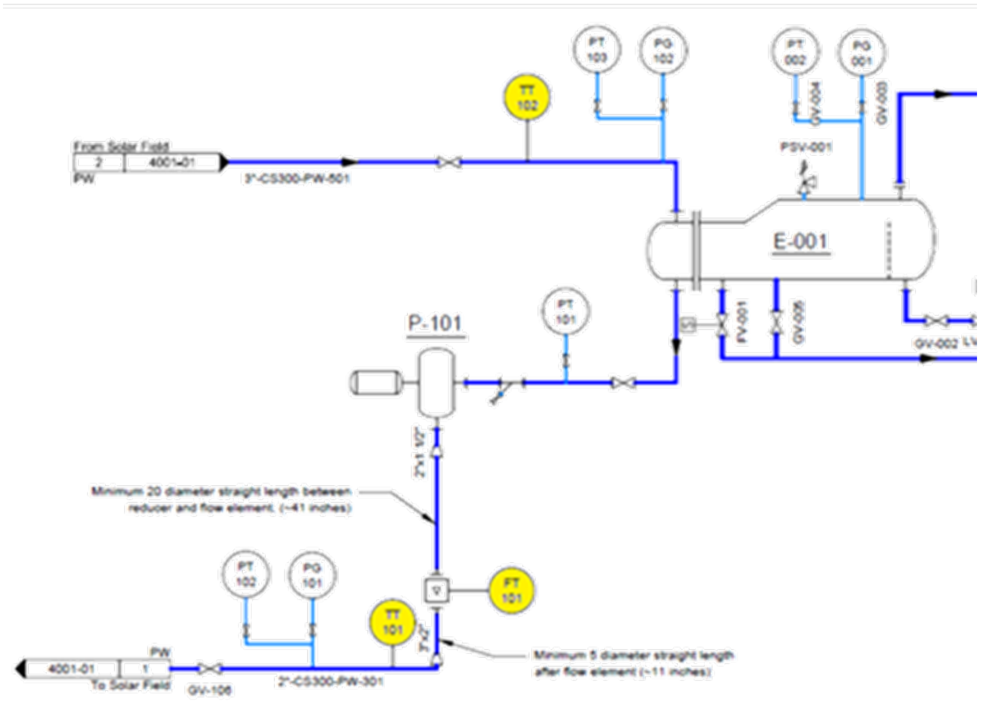
Theory

$$\dot{Q}_{avoided} = \frac{\dot{m}_{HTF}\, c_p (T_{in} - T_{out})}{\eta_{boiler}}$$

BTU meter Specifications

Measurement uncertainty: 3%
Sampling frequency: 30 seconds
Averaging period: 15 minutes

P&ID



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