Fluidized Bed Catalytic Reactor/Receiver for Renewable Fuels and Chemicals

Greg Jackson & Stephanie Kwon
Colorado School of Mines

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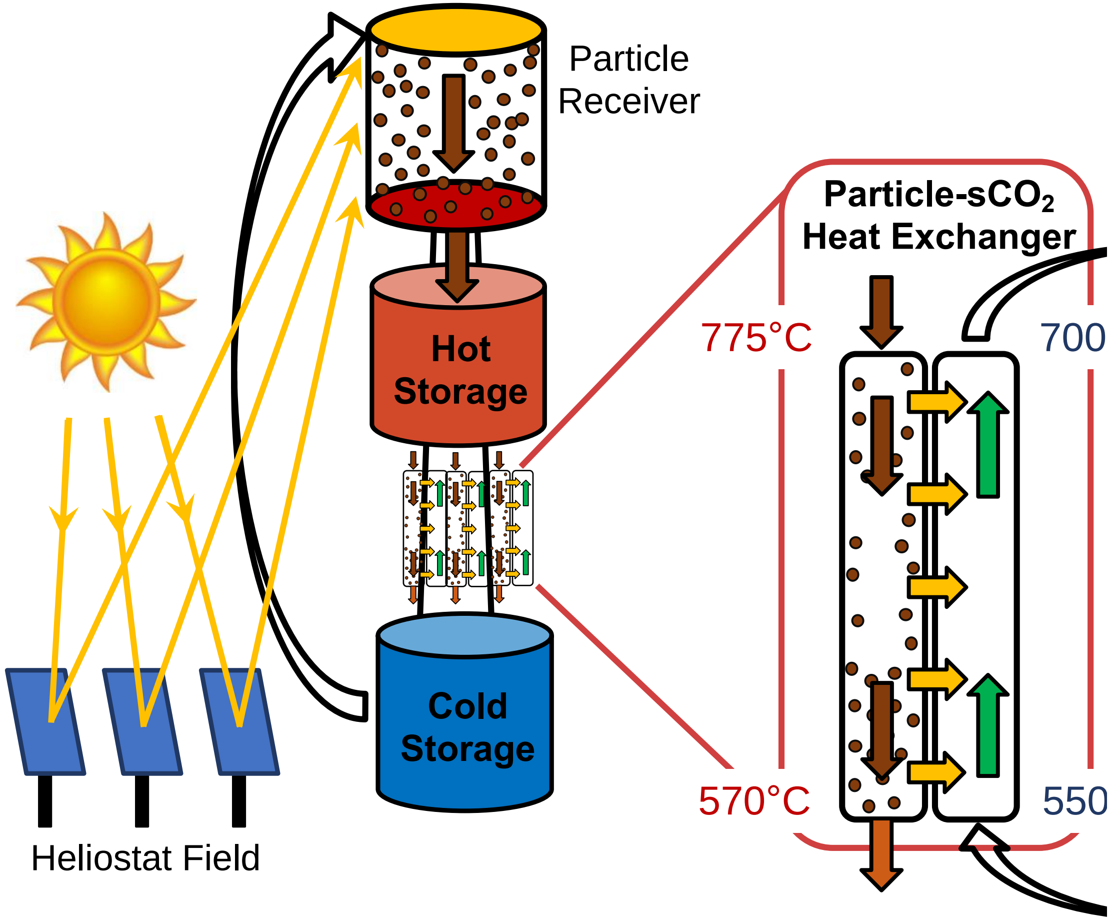
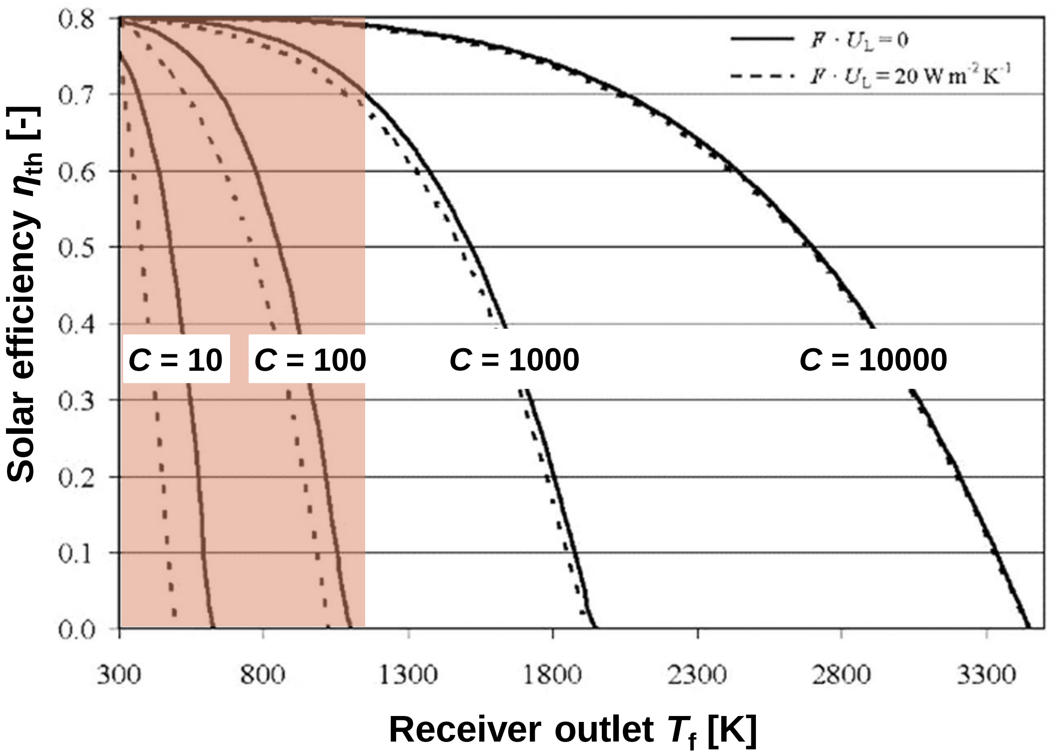
Concentrating Solar Energy Storage



- Concentrating solar technology can capture solar energy at GWh_{th} scale with high efficiency.



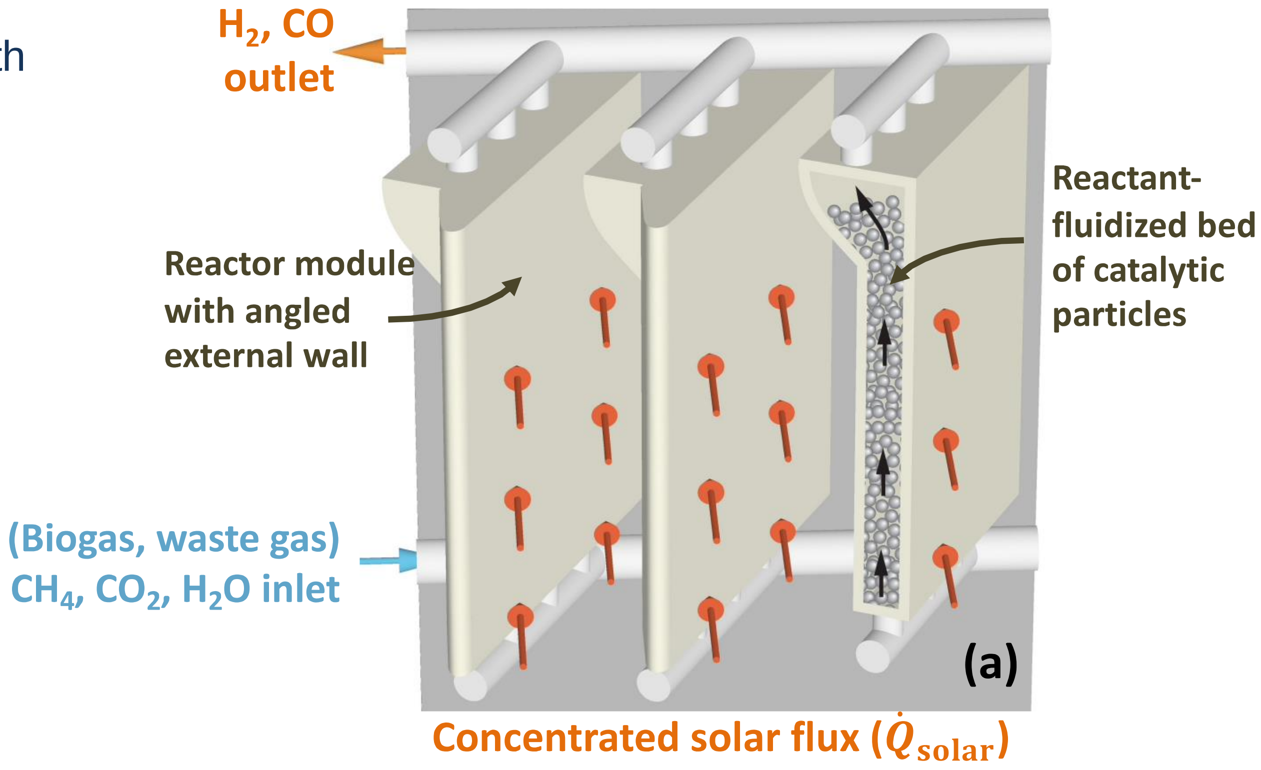
benefits for development and operation.

Concentrating solar receiver efficiency as a function of fluid temperature T_f***, solar concentration ratio C and effective heat loss coefficient*** U_L **(R. Pitz-Paal *EPJ Web of Conferences* 148, 00008 (2017)**

Solar receiver/reactor for syngas as chemical precursor

- Oxide particle energy storage for sCO_2 power cycles requires ≈ 10,000 m^3/GWh_{th}
- Gasoline ≈ 112 m^3/GWh_{th}
- NH_3 ≈ 256 m^3/GWh_{th}
- Solar receiver/reactor can capture solar energy efficiently (> 80%) with angled cavity walls at ≥1000 suns.
- ***Can concentrating solar energy be used to make high energy liquids?***.

Solar-driven fluidized bed CH_4 reformer

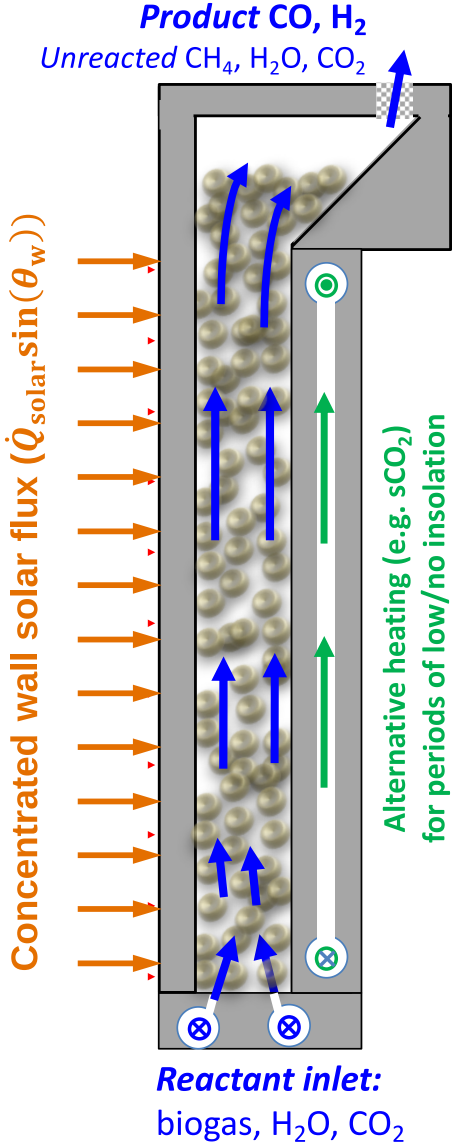


At reactor *T* between 600-700ºC over oxide-supported metal catalysts

Dry reforming: $CH_4 + CO_2 + 260\ kJ/gmol \Rightarrow 2 \cdot CO + 2 \cdot H_2O$

Steam reforming: $CH_4 + H_2O + 206\ kJ/gmol \Rightarrow CO + 3 \cdot H_2O$

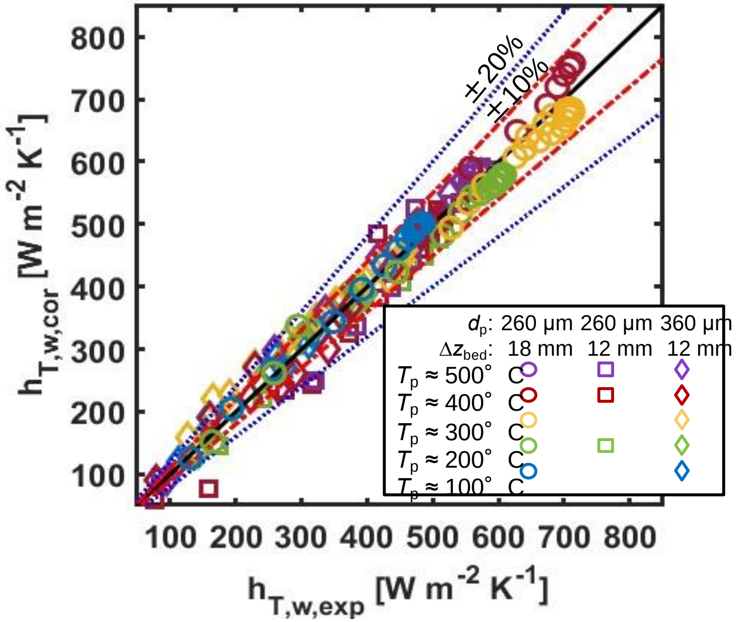
Narrow-channel, fluidized beds for solar reactors



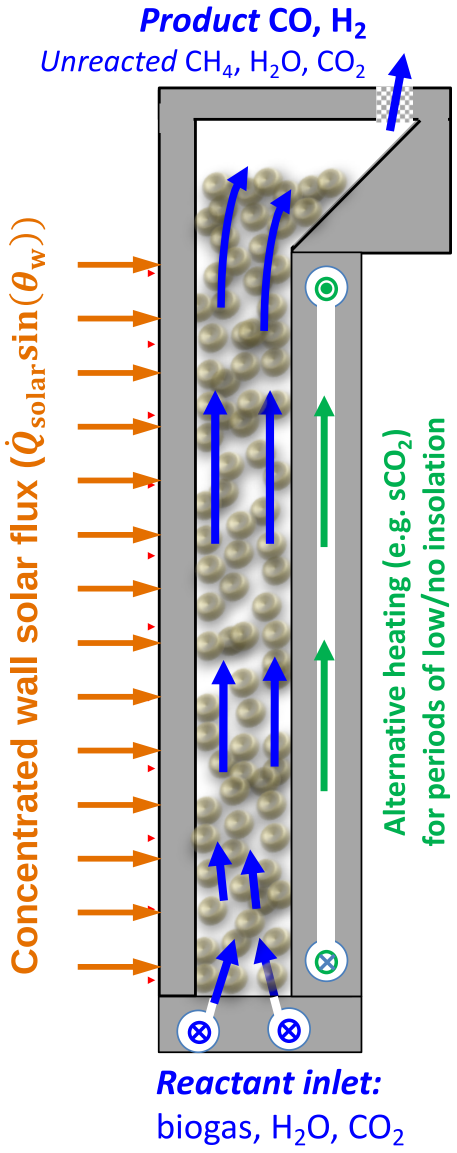
Visualization of narrow-channel fluidized bed

- Narrow-channel fluidized beds can achieve high wall heat fluxes into particles for a solar reactor.
- Extensive testing to T > 500ºC has led to reliable correlations for particle-wall heat transfer coefficients $h_{T,w}$.
- Pathways to $h_{T,w}$ >> 1000 W m^{-2} K^{-1} have been identified and are under development.

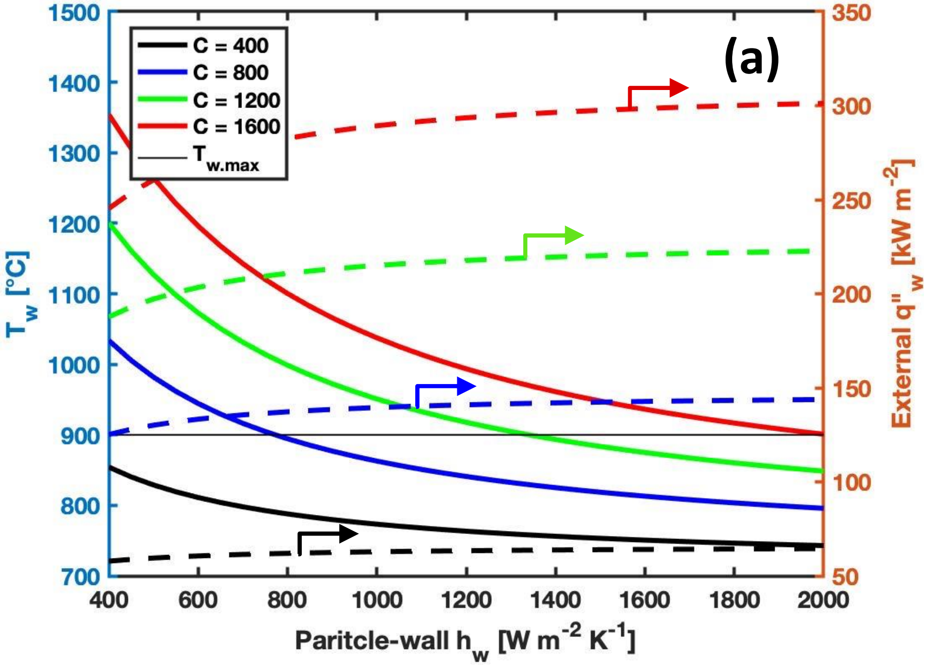
Comparison of experiments with correlations adapted from Molerus (1992)



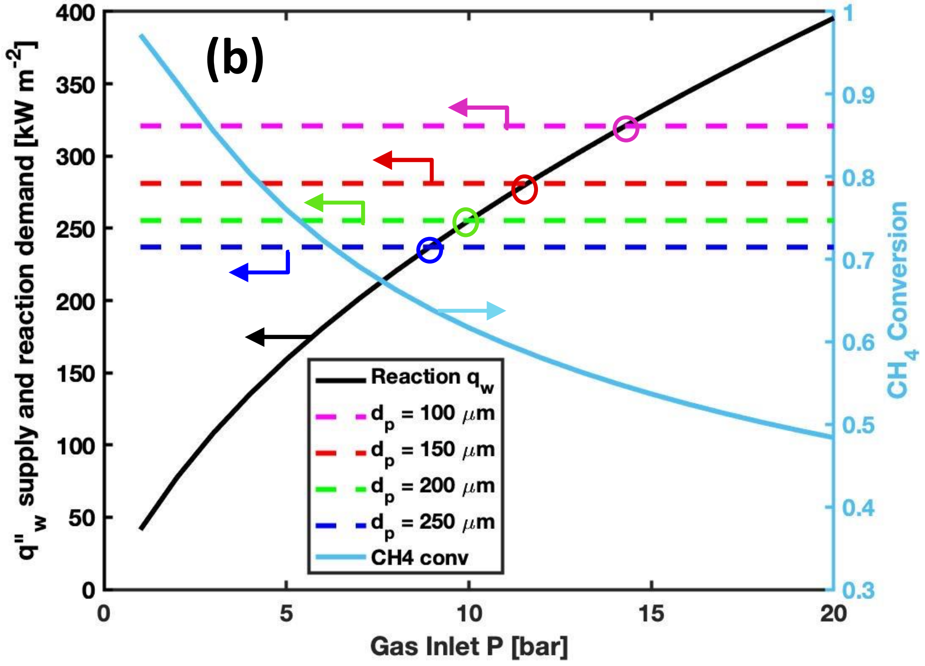
Design and performance of solar-driven reformers



- Catalyst particles and inlet gas pressures can be tailored such that solar wall heat fluxes match reaction enthalpy requirements to achieve high conversion densities for solar driven reactions with wall temperatures amenable for structural metals.



a) Predicted wall T_w and q''_w vs. h_w for solar concentrations C with external wall angles of 12.5° normal to solar flux and reactor T_p = 700°C.

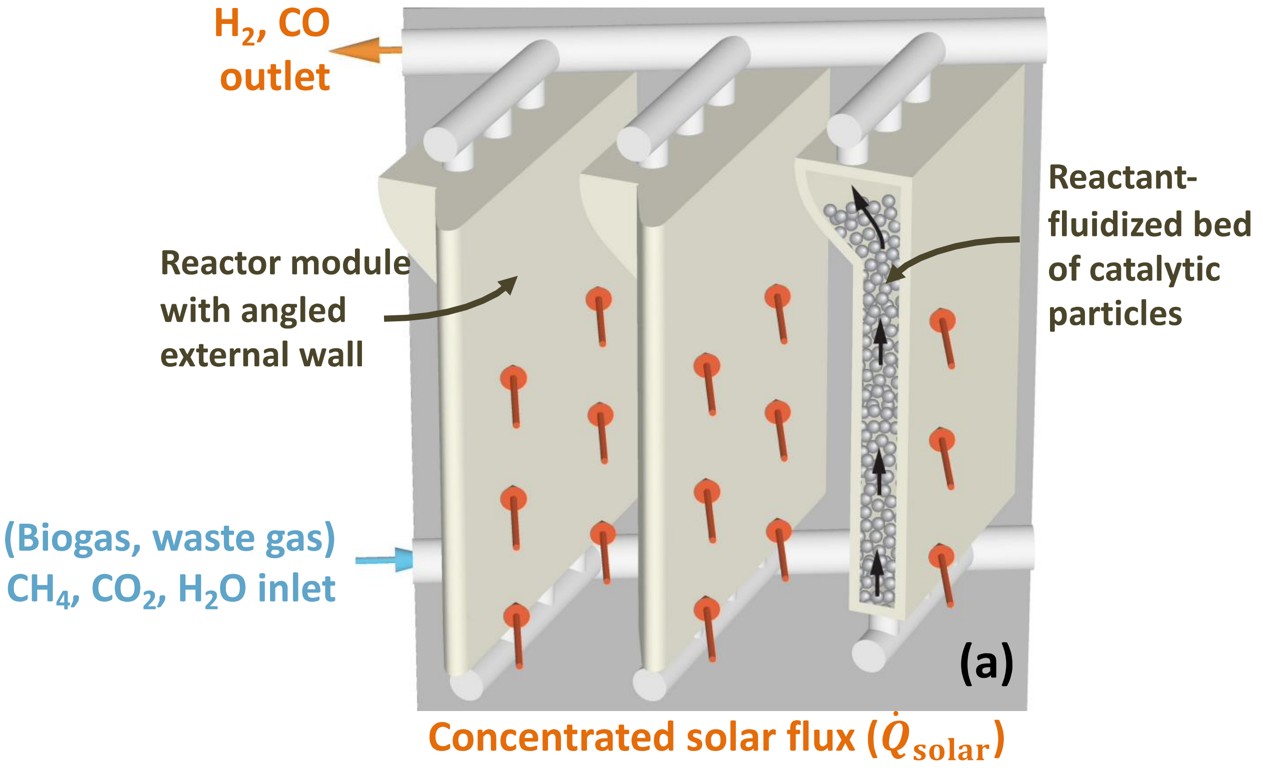


b) Heat flux and CH_4 conversion for reforming 1:3 CH_4:H_2O in 2-cm-deep bed at T_p = 700°C as a function of inlet P for 4 particle diameters d_p of Ni/Al_2O_3 catalysts.

Solar reactors for renewable fuels

- Solar energy can react biogas, waste gas, and/or recovered byproducts with CO_2/H_2O to liquid fuels through F-T process or NH_3 through H-B process.
- Solar reactor receiver can use state-of-the-art catalysts with particles sized to optimize heat transfer to support high-wall fluxes for cost effective systems.
- Efficiencies
  - solar to syngas > 80%
  - syngas to liquid fuels via F-T ≈ 50%

Solar-driven fluidized bed rCH_4 reformer



Solar reactor/receiver can be integrated with known infrastructure to provide cost-effective, low-to-zero carbon footprint fuels and chemicals