Novel Binderjet Additive HXs

A Pathway to 5¢/kWh CSP

September 20, 2021

Naveenan Thiagarajan, William D. Gerstler, Ananda Barua, Daniel Erno,
Yongxiang Wang, Lana Osusky and Shenyan Huang

General Electric Research – Niskayuna NY

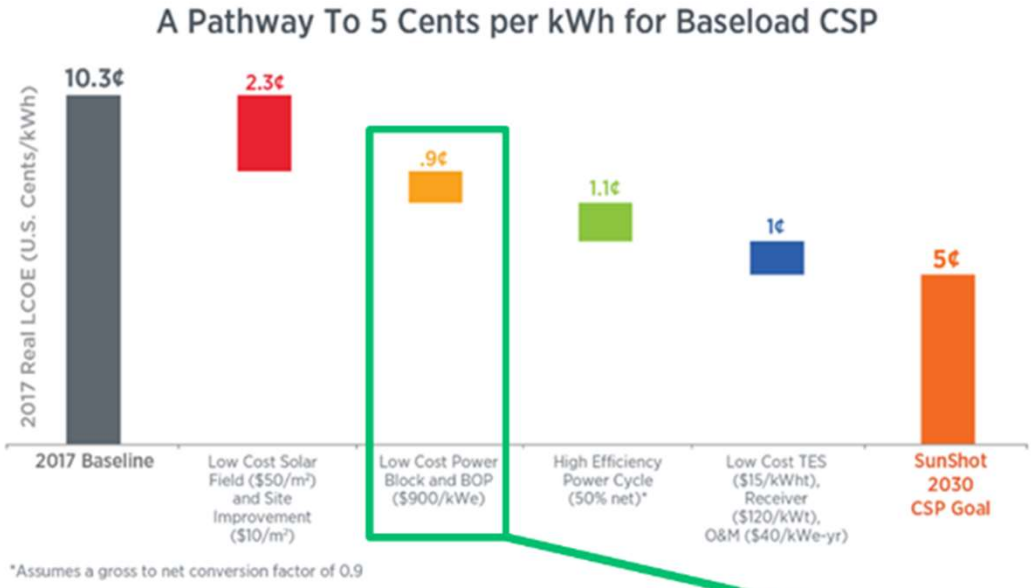
Acknowledgments

The authors wish to acknowledge the work of the following individuals, without which this research would not be possible:

John Morrison
Bill Alberts
Will Navojosky
Pong Chan

This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Solar Energy Technology Office (SETO) Award Number DE-EE0008737.

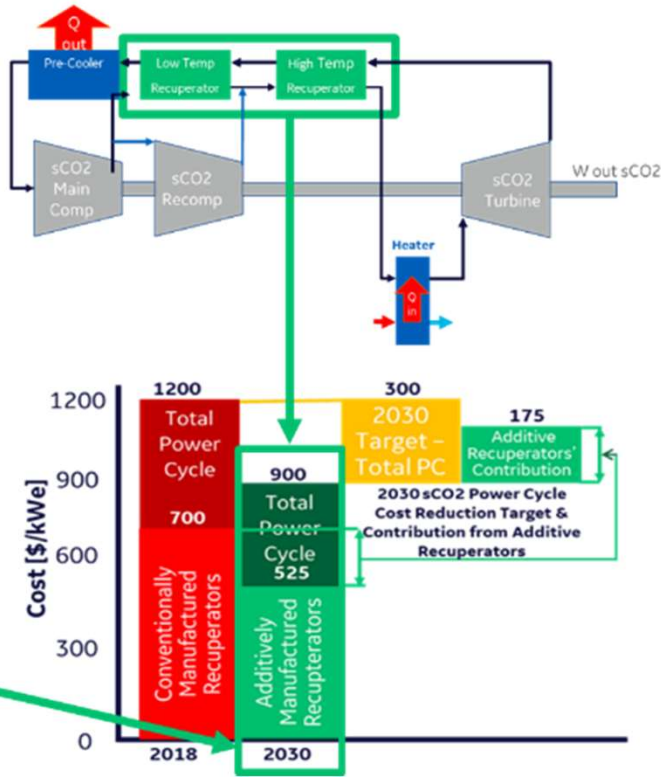
Heat Exchangers: CSP Power Cycle Cost Driver



A proposed path towards $0.05/kW-h from CSP [DOE/EERE, 2018]

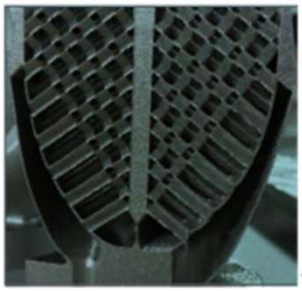
Binderjet HX's reduce Power Block Cost

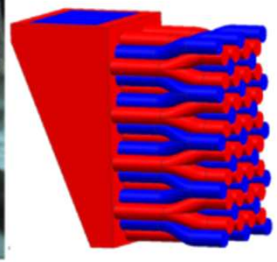
sCO2 Recompression Cycle: Recuperators dominate the cost



Complex Design: A Challenge for Binderjet

Planar Trifurcating HX core geometry





Trifurcating flow channels

Boundary layer resets at every 1-3 D_h

3x HTC laminar flow

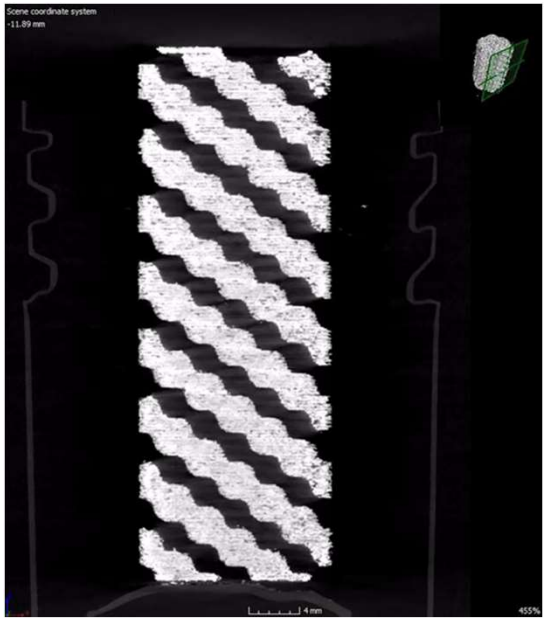
1.2-1.3x HTC turbulent flow

Massively parallel flow paths

Core geometry extends into manifold

From Planar to curved Unit Cell: reduces stress >50%

Multiple small internal passages & powder removal



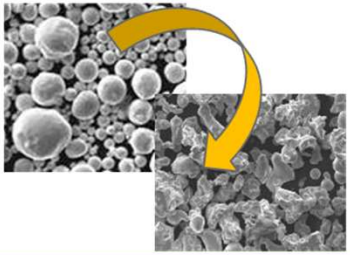
Binderjet Process & Advantages

High Throughput

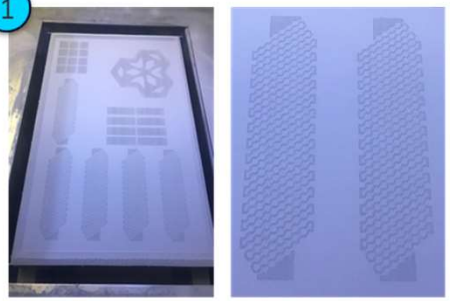
- Faster print speeds compared to powder bed fusion;
- Batch processing.

Lower Cost Print Process ($/cc)

- Gas atomized → water atomized powder;



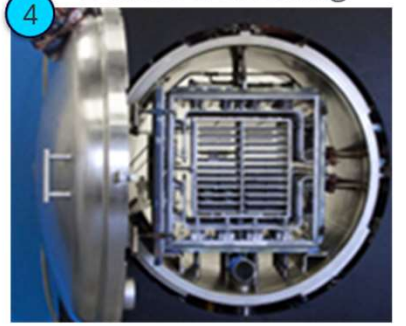
1 **Binder Jet Print**



2 **Binder Curing**

3 **De-Powdering**

4 **Debind & Sintering**

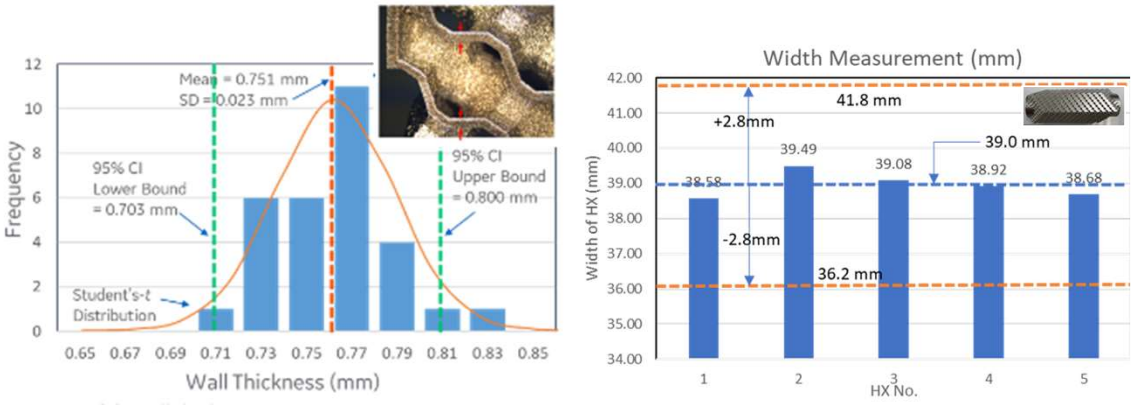


5 **Heat Treatment (Optional)**

6 **Finished Part**

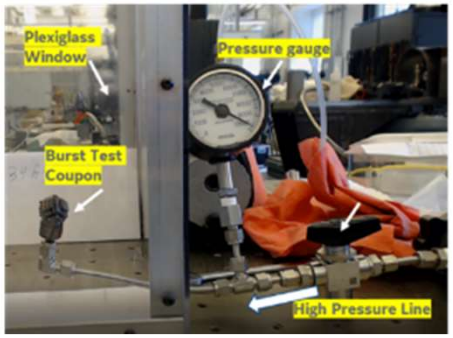
Builds demonstrate control and high quality

Dimensional control



- At 0.75 mm, wall thickness within target range of ± 0.2mm
- Hole diameters within ± 0.25 mm
- Overall dimensions within target within ± 5 mm

Burst pressure

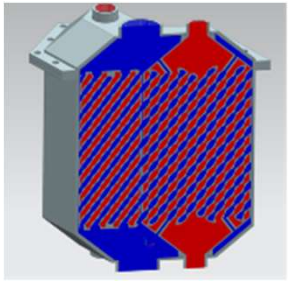


- Core sections subjected to high pressure on one side
- Successful demo of pressure sustainability @ 10,000 psi

Modular HX Concept & Cost Breakdown

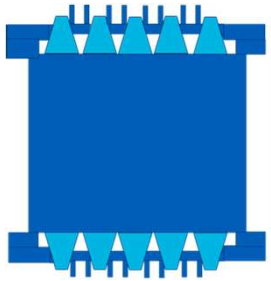
Concept for Full Size Heat Exchanger
Binderjet HX Cores Combined into Modular Units

3 core units

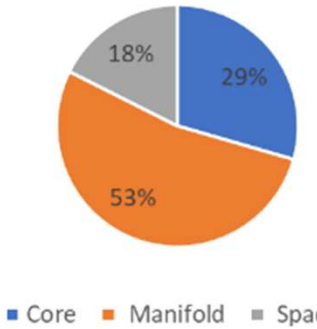


X-section

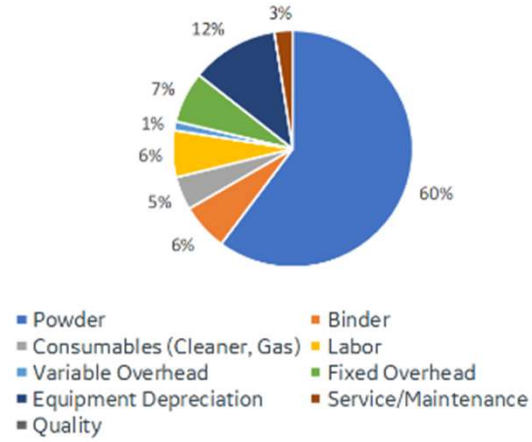
Side view



Total HX Cost

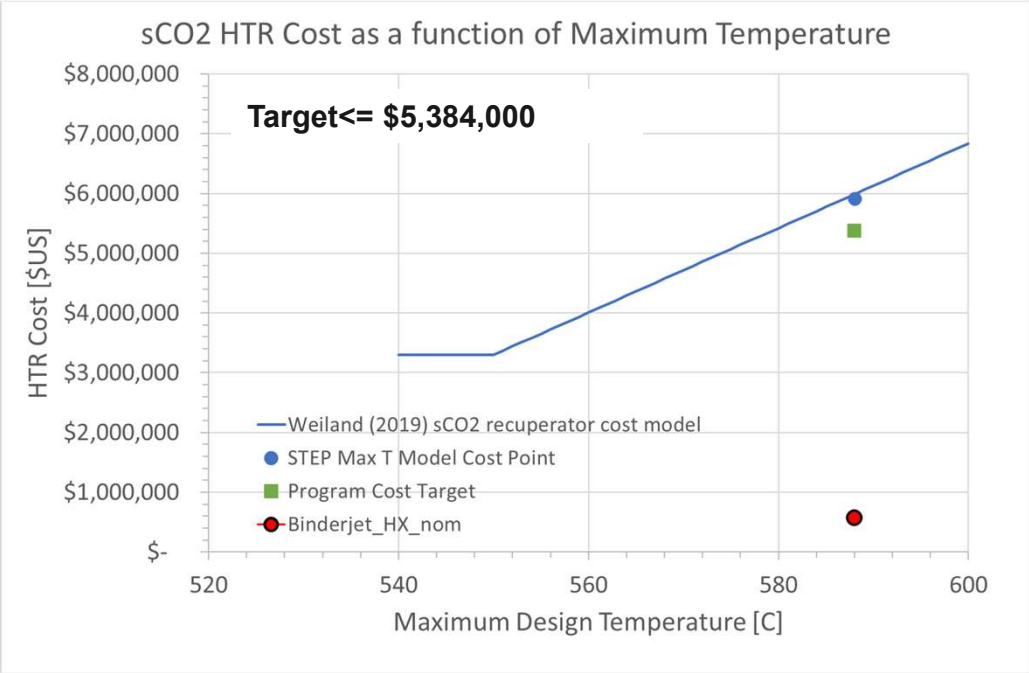


Core cost breakdown



Powder cost is a significant cost driver

Cost Target < 90% Weiland Model



Cost estimates well within target

Estimate does not include assembly and inspection but have significant margin

Additional cost reduction potential

HX core size & build orientation
Modular HX design
Power cost etc.

Summary

- CSP sCO2 Power Cycle Cost is limited by Recuperator Cost
- Binderjet – Technology with High Throughput and Low Cost
- **Complex Core Geometry** – Successful builds using Binderjet demonstrated *within targets and tolerances*
- **HX cost within targets** with potential for additional reduction