Oregon State University

High Flux Microchannel Receiver Development

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Award # DE-EE0007108
Presented at SETO CSP Program Summit
March 19th, 2019

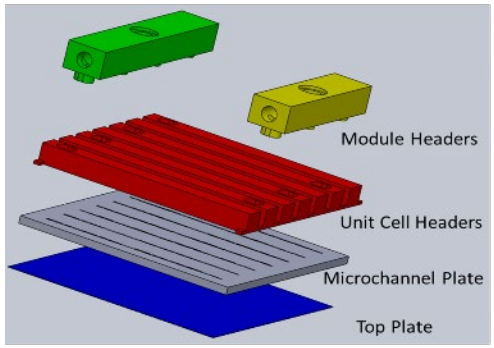
COLLEGE OF ENGINEERING

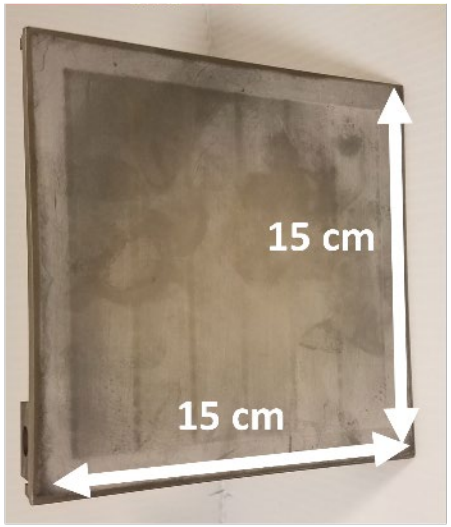
School of Mechanical, Industrial, and Manufacturing Engineering

sCO_2 High Flux Receiver Development

Project Goals

- Receiver efficiency > 90%
- sCO_2 from 550°C to 720°C
- P = 250 bar
- < \$150/kW_{th}
- > 10,000 cycle life





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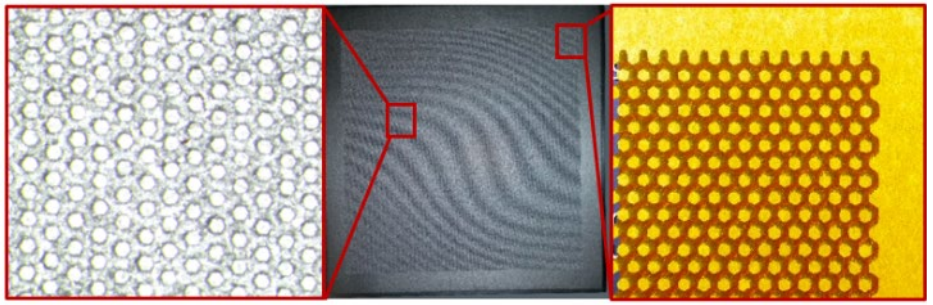
Micro-Pin Receiver Concept

Advantages

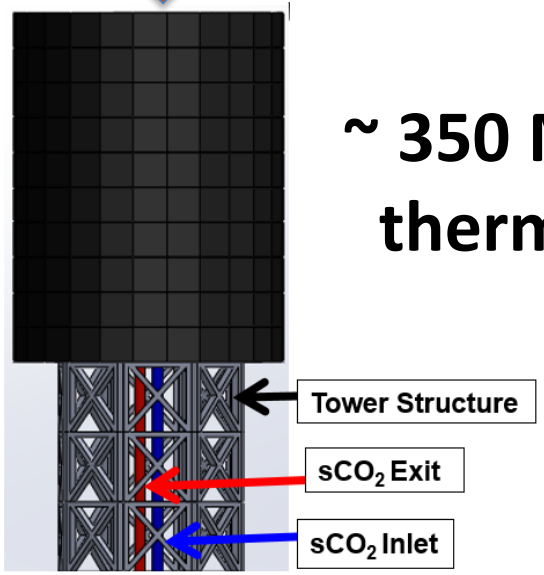
- D_H ↓ h ↑
- Thin walls
- Reduced material
- Modularity

Challenges

- Thermal hydraulic
- Materials
- Manufacturing
- Reliability

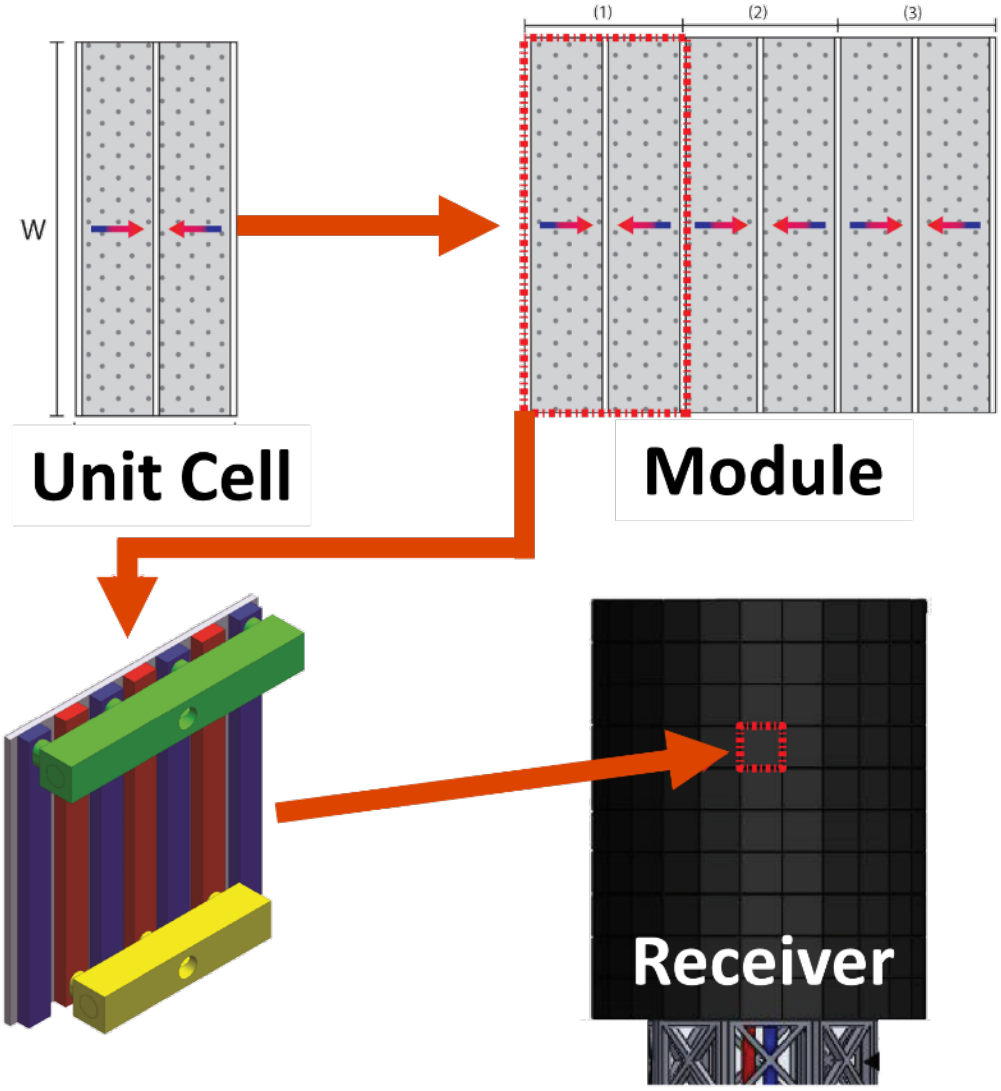


~ 300 µm



~ 350 MW thermal

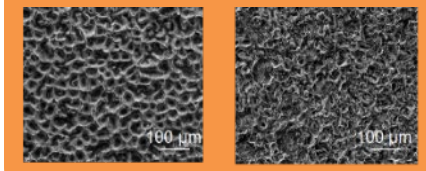
Approach: Numbering-Up Concept



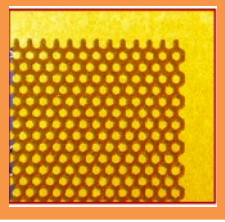
K.R. Zada, M.B. Hyder, M. Kevin Drost**, B.M. Fronk**, Numbering-up of microscale devices for megawatt-scale supercritical carbon dioxide concentrating solar power receivers, J. Sol. Energy Eng. 138 (2016) 61007. doi:10.1115/1.4034516.

Technology Development TRL 3→5

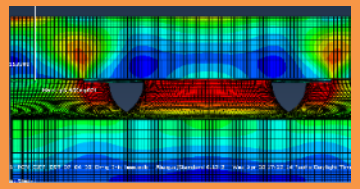
Materials



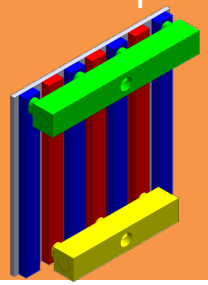
Fabrication Methods



Thermal and Mechanical Limits



Component Concept

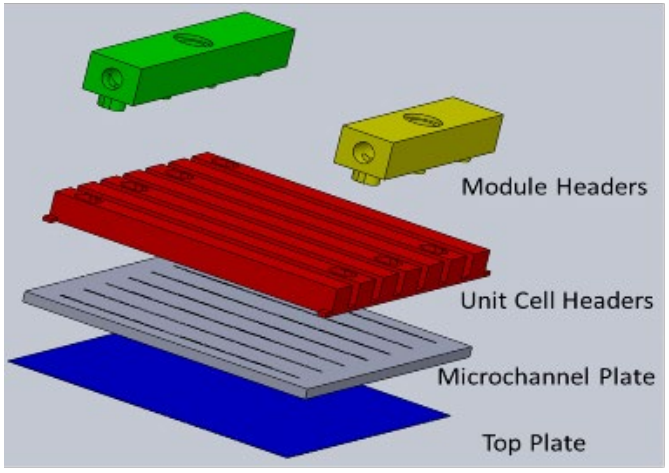


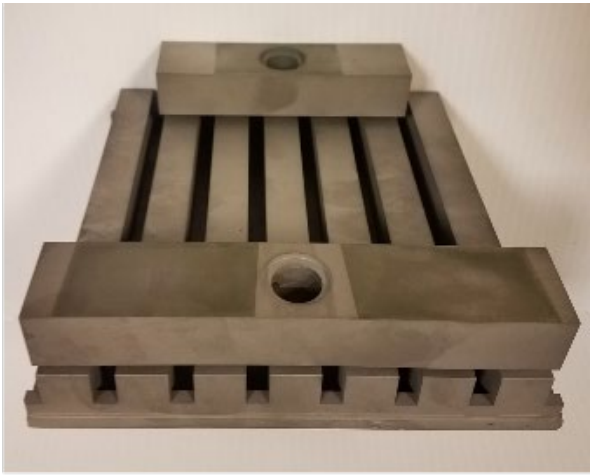
Prototype Evaluation

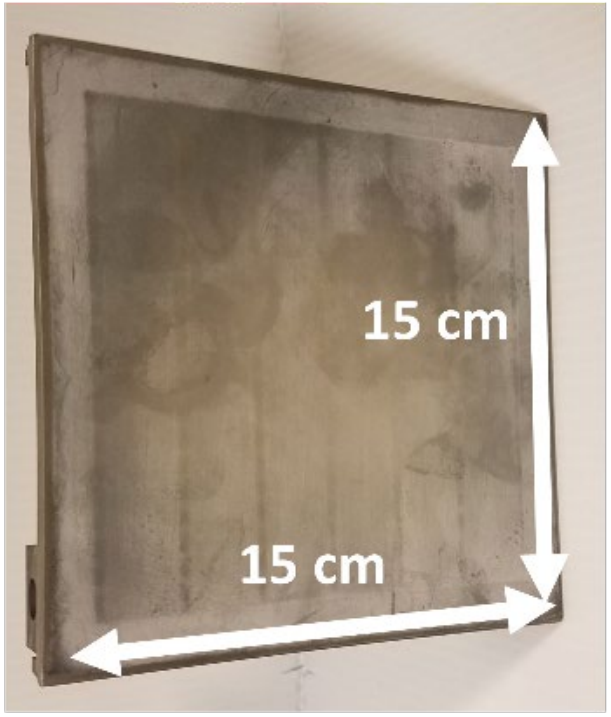
System Analysis

Cost Model

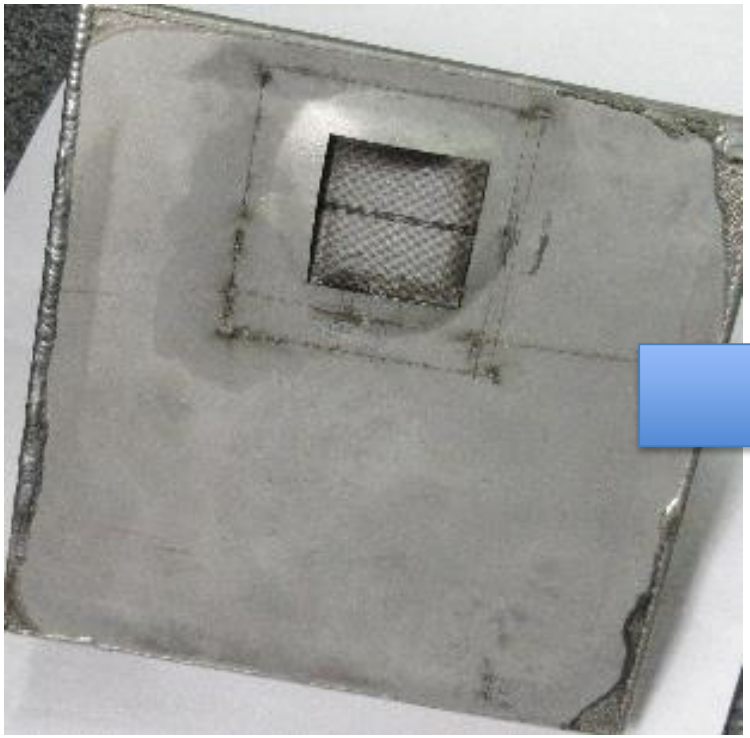
Prototype Development

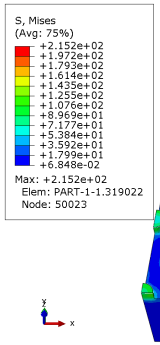


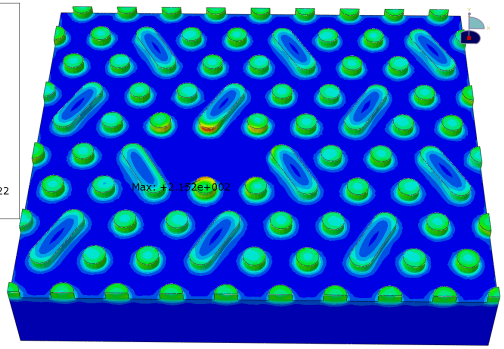


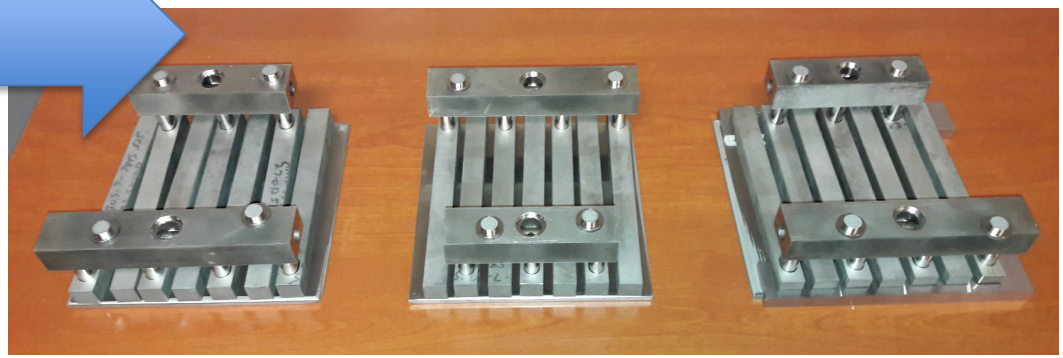


Impact – Design, Materials and Fabrication









- Joining high temperature nickel alloy
- Qualifying vendors (machining, etching, etc.)
- Ongoing work to mitigate identified failure modes

Impact – On Sun Demonstration

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- Phase 1 prototype
- Direct heating of sCO_2
- 8 cm x 8 cm

Impact – Performance Goals

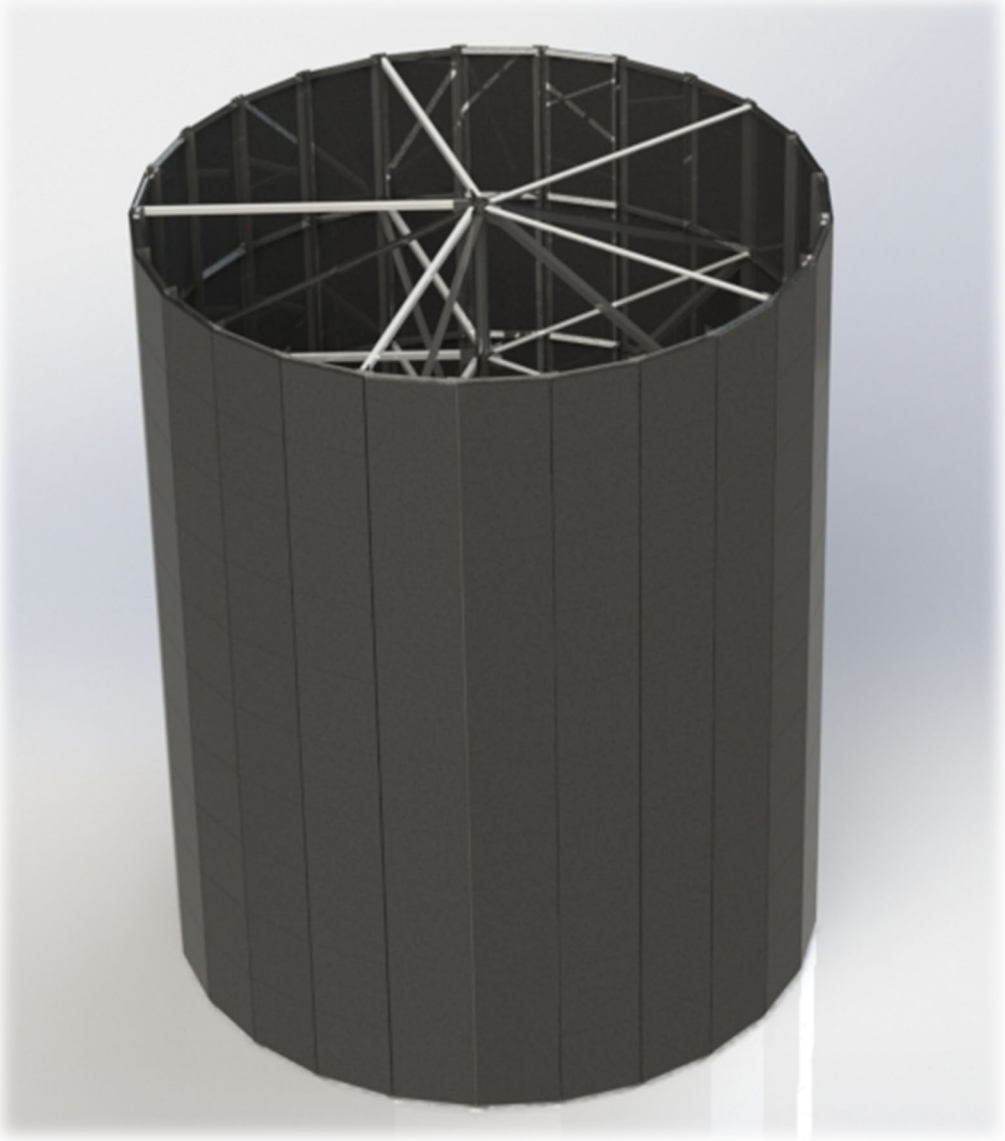
- Based on experimentally validated thermal models **OSU predicts receiver efficiencies that exceed Sunshot Goals for both supercritical CO_2 (91% to 93%) and molten salt (90% to 93%)**

- Based on an experimentally validated mechanical model **OSU predicts pin array life times that exceed 12,000 thermal/pressure cycles** meeting Sunshot Goals for supercritical CO_2. Due to low pressure, this is not expected to be an issue with molten salt

- Based on experimentally validated thermal models **OSU has shown that the MSR applied to molten salt can have a 30 year life with corrosion rates of 15 microns per year** and meet Sunshot receiver efficiency goals

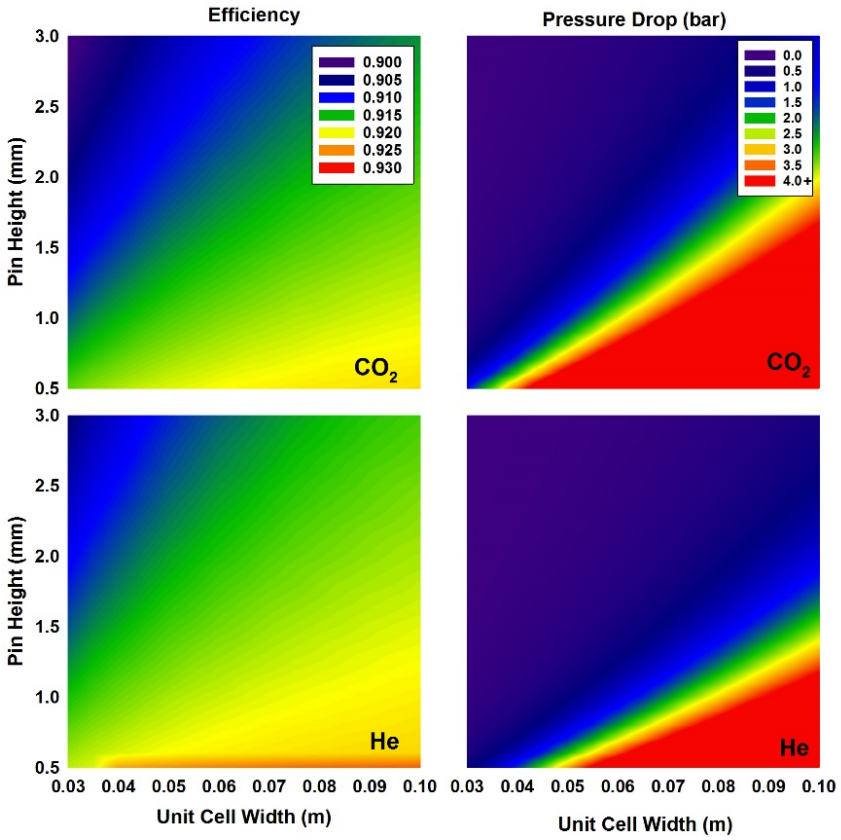
Impact – Cost Targets

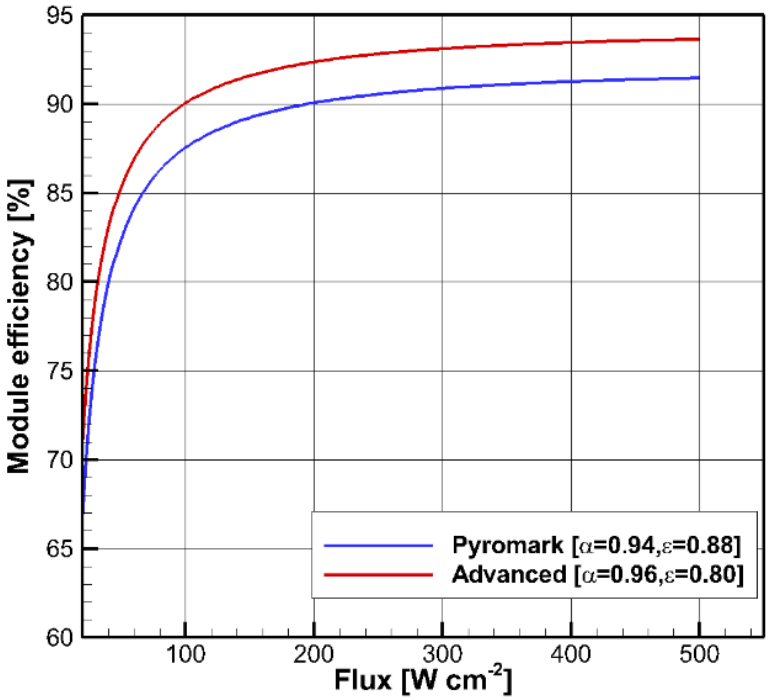
Pacific Northwest
NATIONAL LABORATORY



Receiver Elements	Costs
Solar Receiver Capacity	350,000 kW_t
Valves	$4,525,000
Receiver Piping (inlet)	$32,098
Receiver Piping (Outlet)	$411,790
Inlet Piping #1	$54,915
Outlet Piping #1	$704,220
Inlet Piping #2	$8,827
Outlet Piping #2	$100,826
Inlet Connectors	$8,781
Outlet Connector	$56,284
Structural Members	$62,693
Losses (2%)	$28,809
Welding	$711,542
Transportation	$6,600
Crane	$108,852
Modules	$6,194,500
Total Direct Costs	$13,015,737
Contingency (10%)	$1,301,574
Total Cost	$14,317,311
Cost/kW_t	**$40.90**

Impact – Gen3CSP Pathways

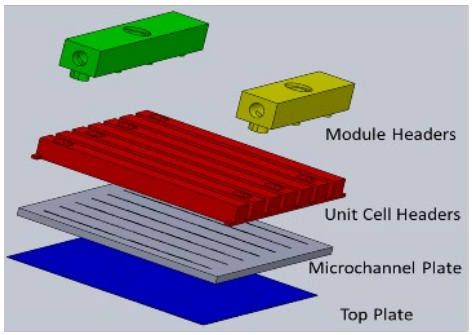


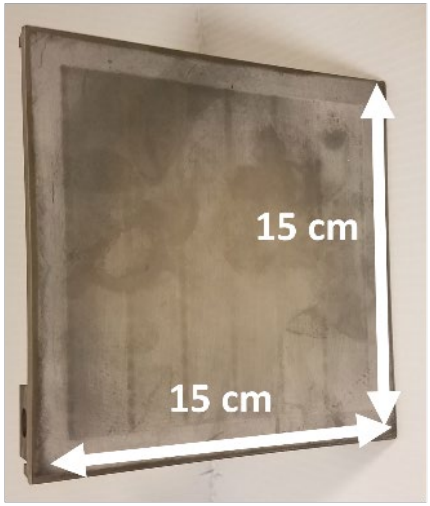


- Designs developed for lower pressure sCO_2, He, molten salt with >90% efficiency
- Cost advantage increase at lower pressure

Looking Forward

- Pathway to megawatt scale demonstrated
- Modular concept advantageous
  - Tailored receiver design
  - Manufacturability
- Detailed investigation of joining processes
- **On-sun testing to 720 °C**
- Larger format prototypes with at-scale fabrication techniques





Acknowledgments

Oregon State University
- Kevin Drost
- Brian Paul
- Sourabh Apte
- Rajiv Malhotra

UC-Davis
- Vinod Narayanan
- Erfan Rasouli

NETL
- Omer Dogan
- Kyle Rozman
- Matt Carl

PNNL
- Mark Weimer

SNL
- Kevin Albrecht
- Clifford Ho
- Matt Carlson

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