Solar Powered Water Heating Technology Research

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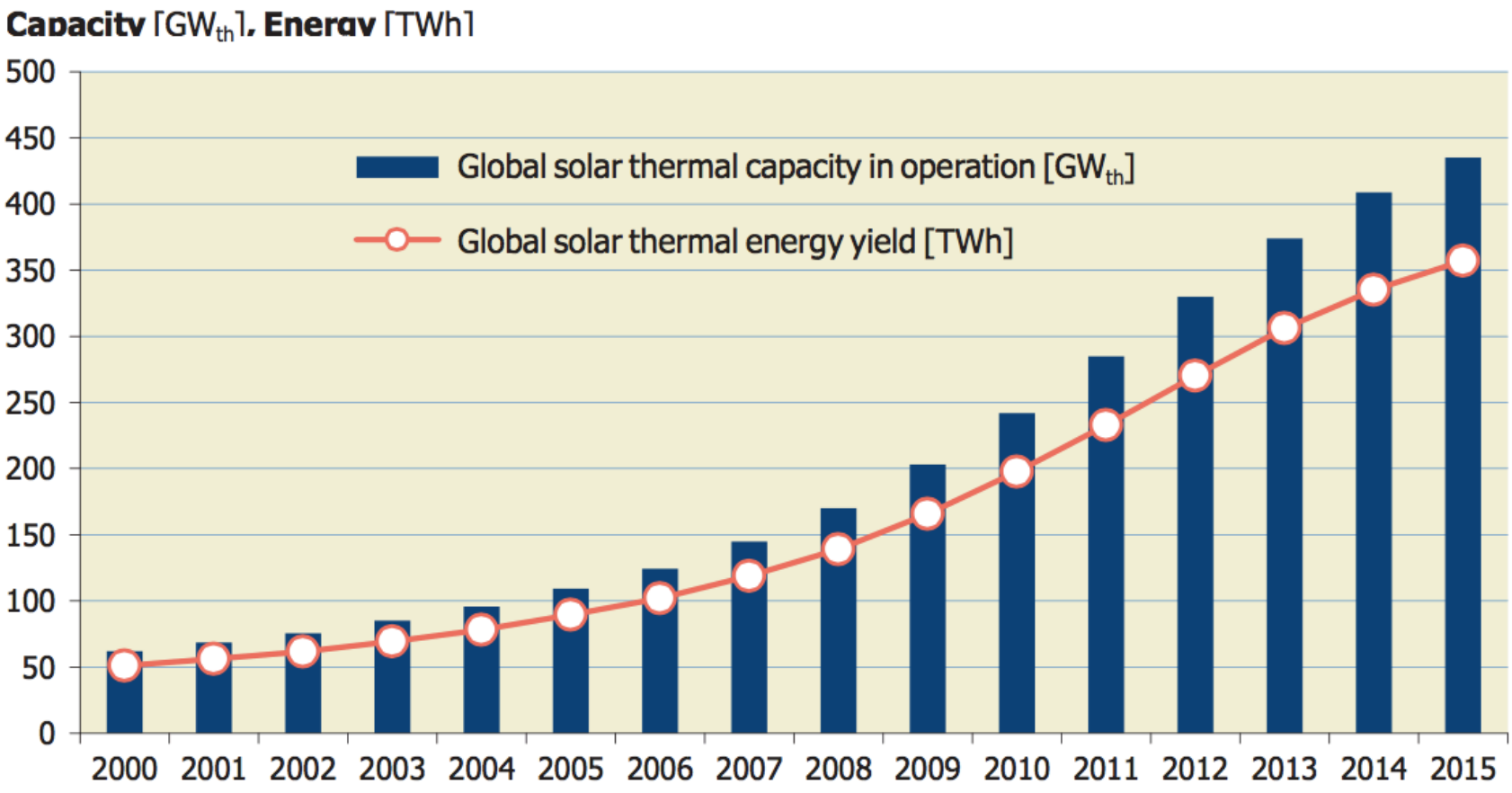
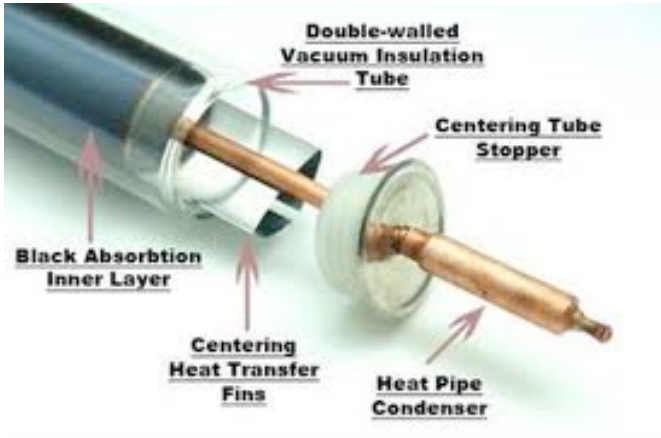
Global Capacity and Energy Yield

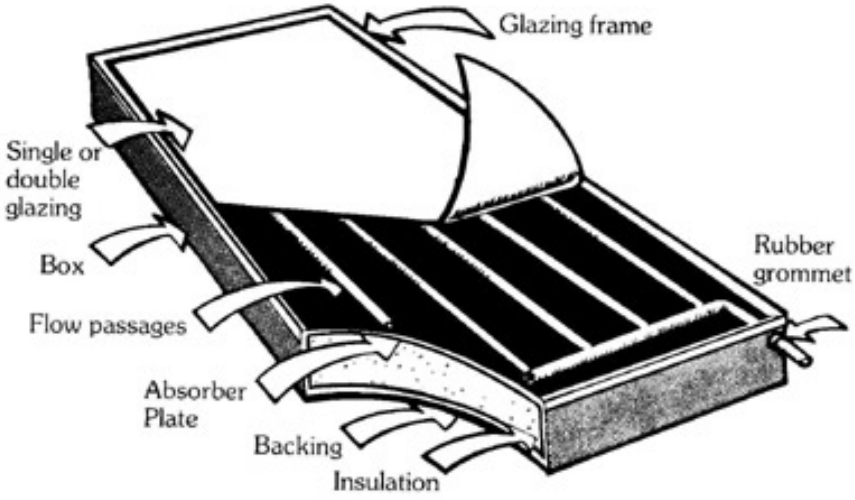


Global solar thermal capacity in operation and annual energy yields

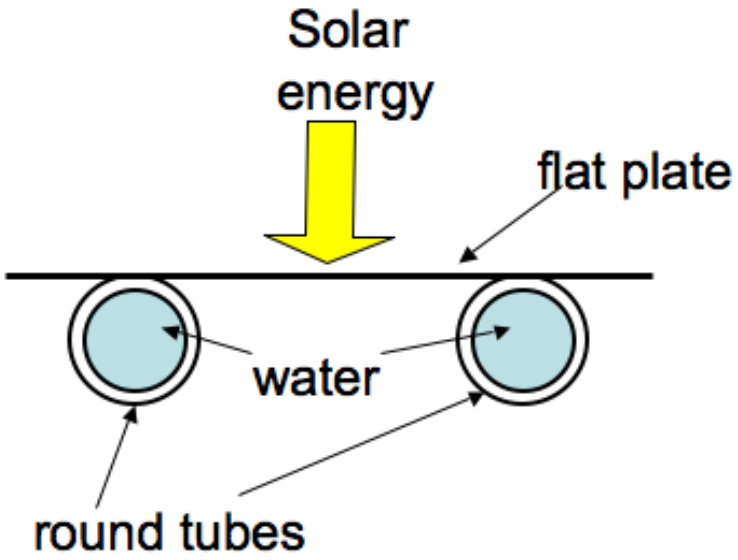
Solar Heat Worldwide, Markets and Contribution to the Energy Supply 2014. 2016 Edition

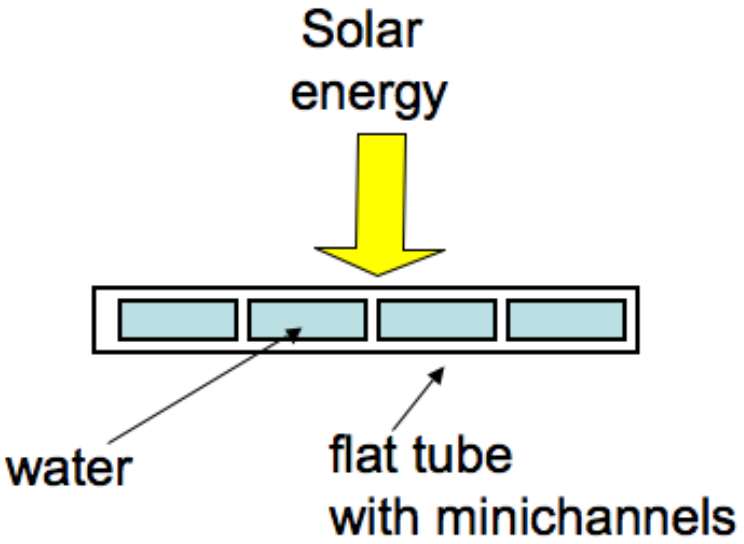
Solar Collector Configurations

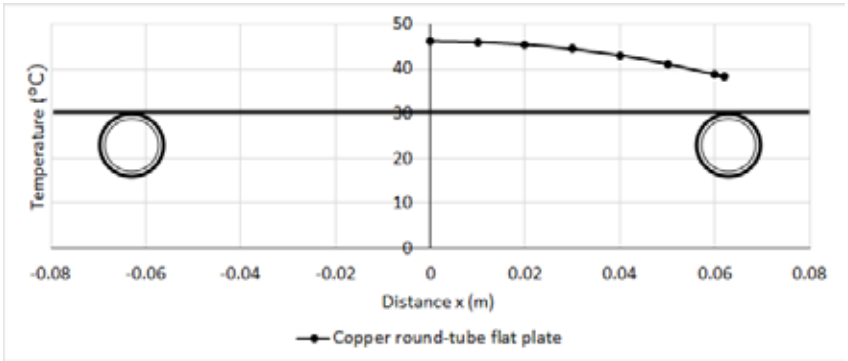


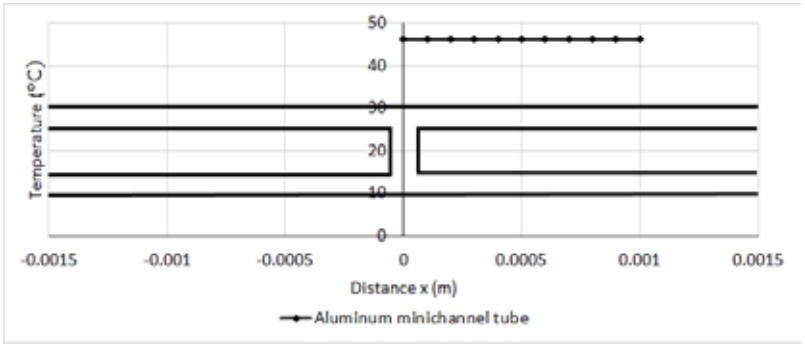


Minichannel tubes and Solar Energy

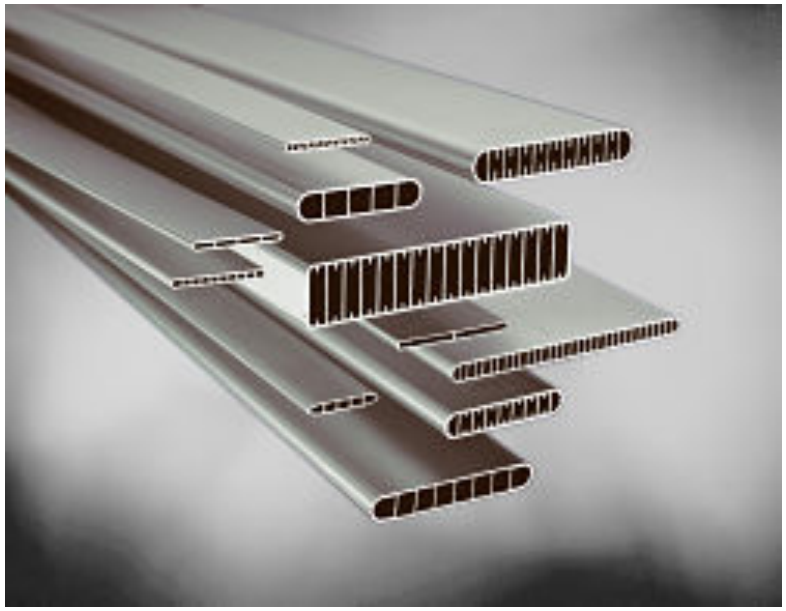


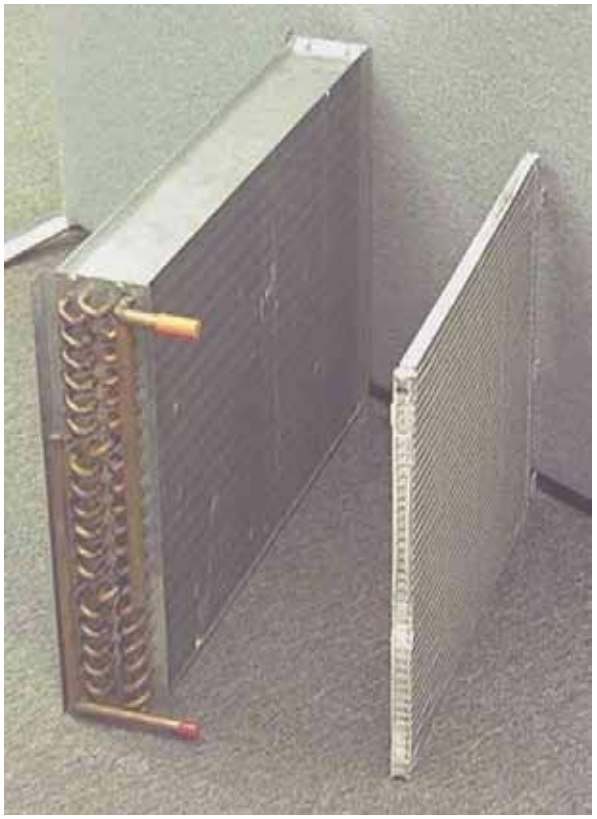






Types of Minichannel Tubes

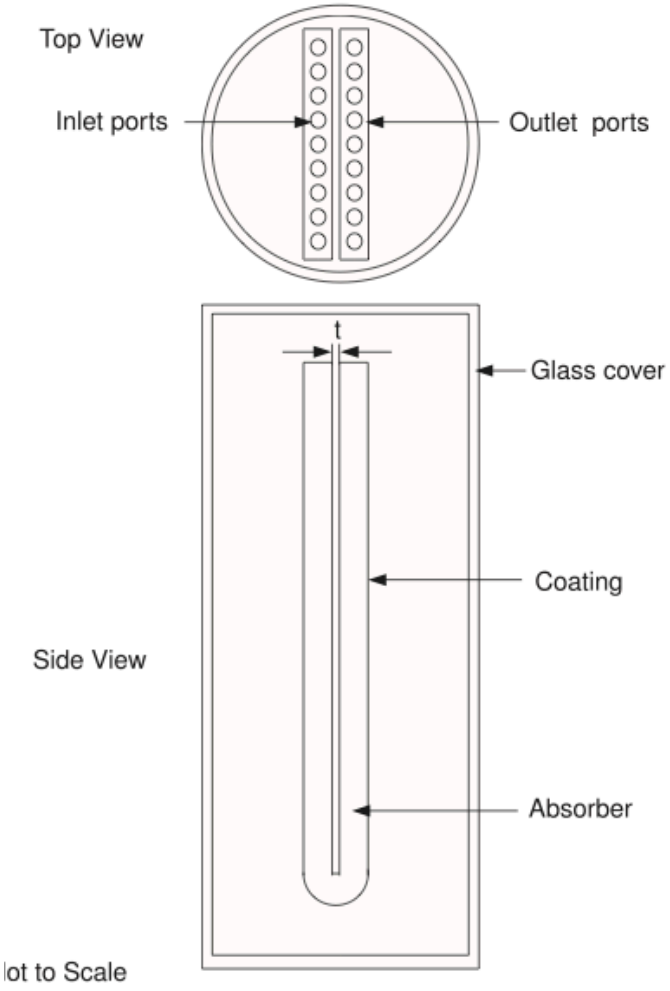




Aluminum Minichannel Condenser versus RTPF Condenser

Equal Capacity: 7 kW

Improved Thermal Efficiency



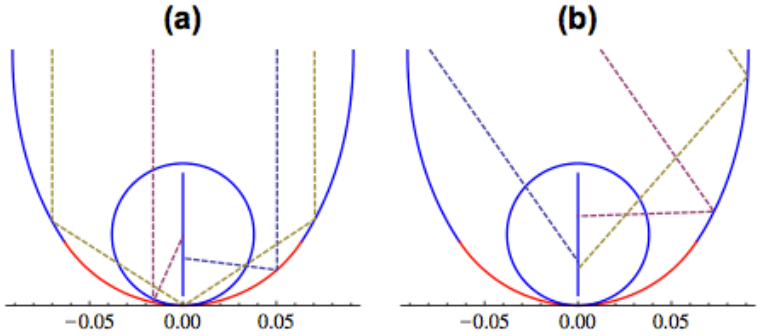
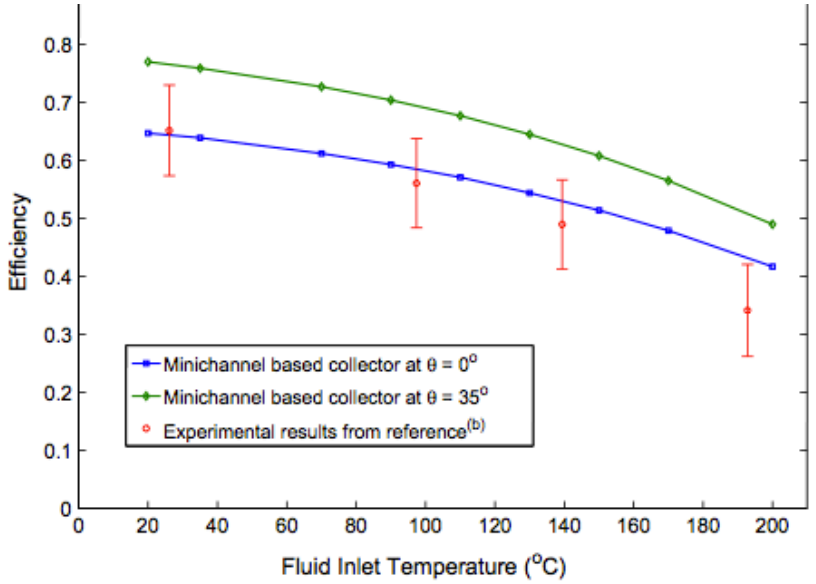


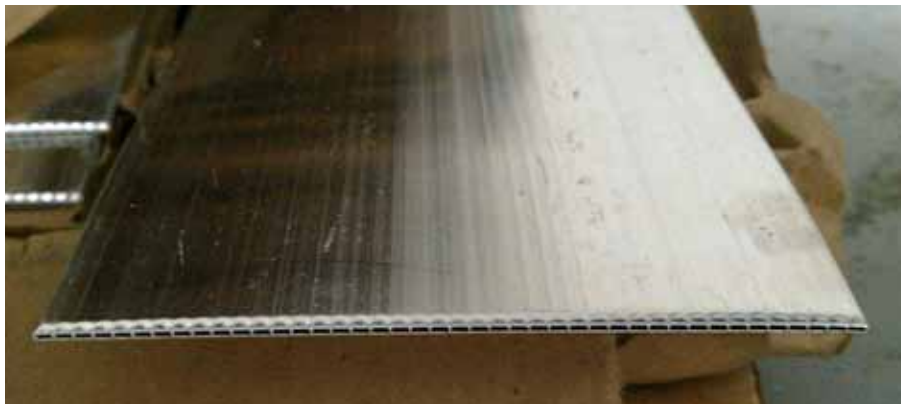
Fig. 10. Cross-section profile of the CPC concentrator for the minichannel-based solar collector. Three sample rays out of 50,000 are shown for (a) $\theta = 0°$ and (b) $\theta = 35°$.



N. Sharma, G. Diaz, Solar Energy, 85 (2011) 881-890

Diaz G., Sharma N. US 2011/0186043 A1, 2011

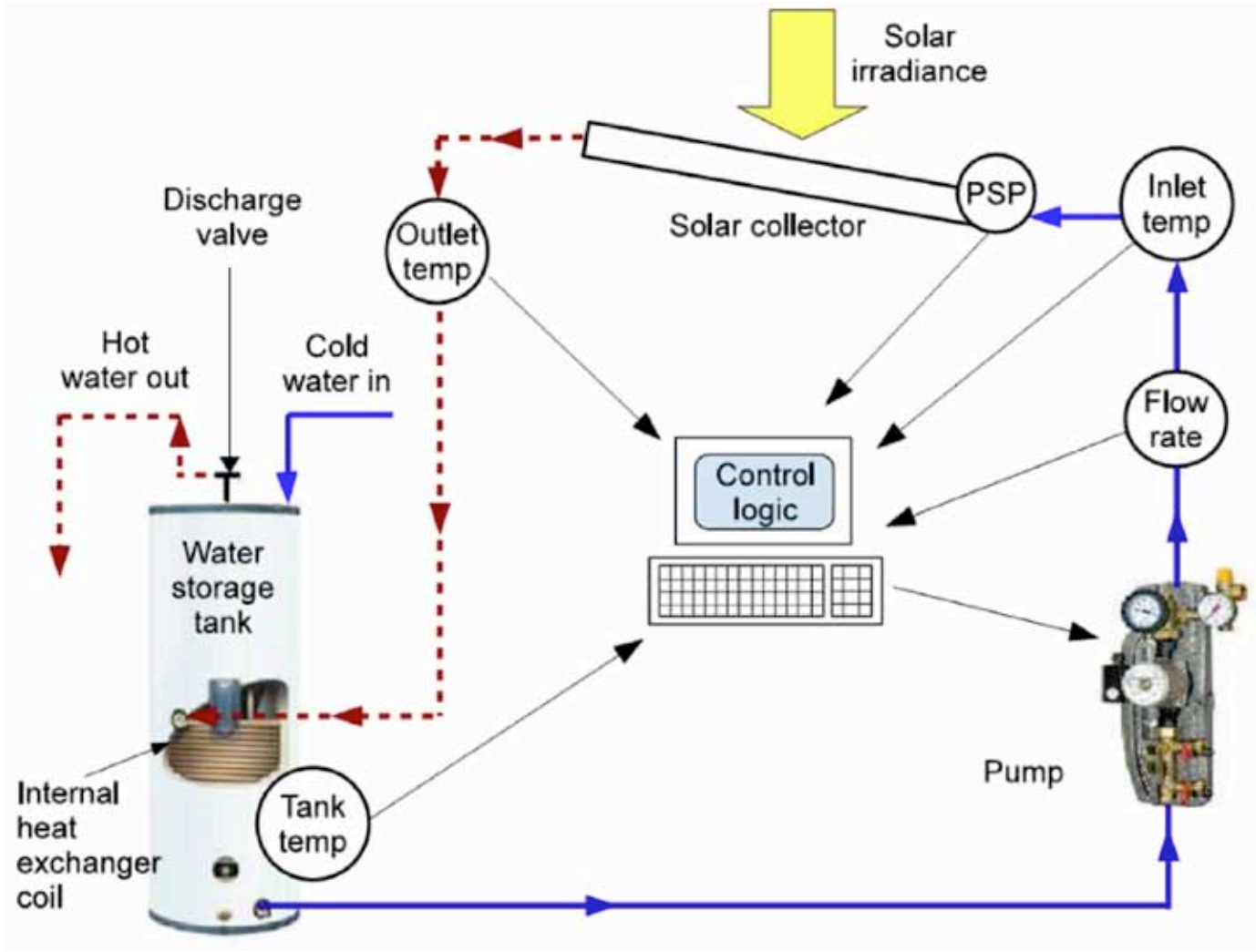
Aluminum Minichannel Collector



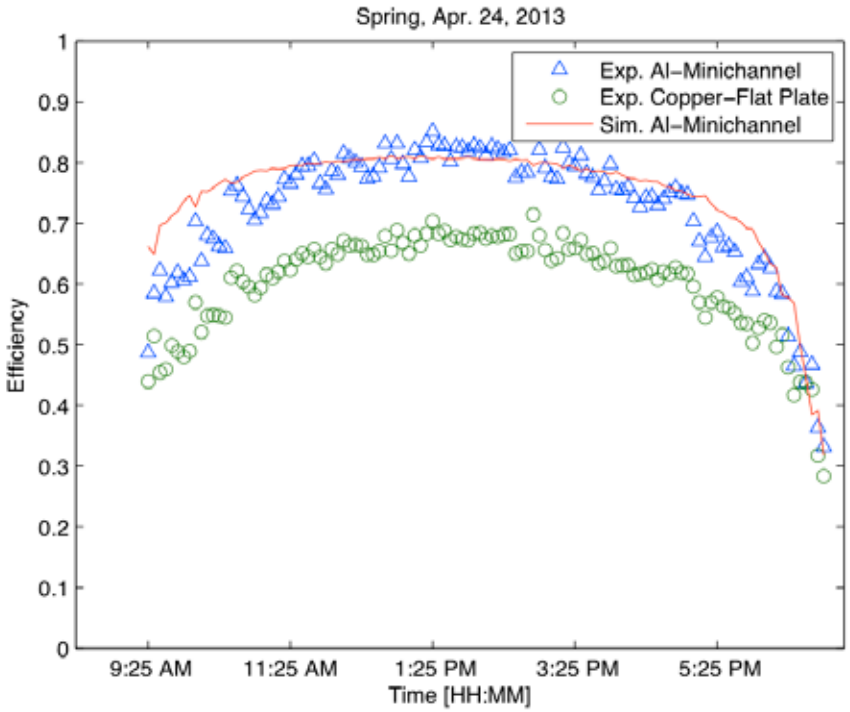
Minichannel tube by Hydro

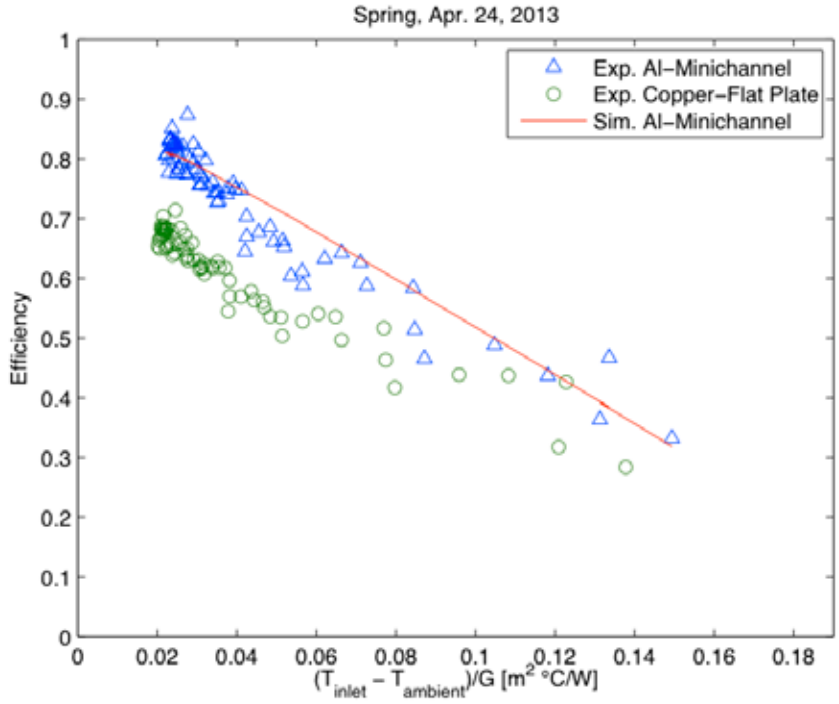
Selective coating: Black chrome (EC series): α=.95, ε = .12

Closed-Loop System



Thermal Efficiency





Thermal Efficiency Improvement: 12%, approximately

Robles et al., Solar Energy, 110 (2014) 356-364

Prototype Collector Cost

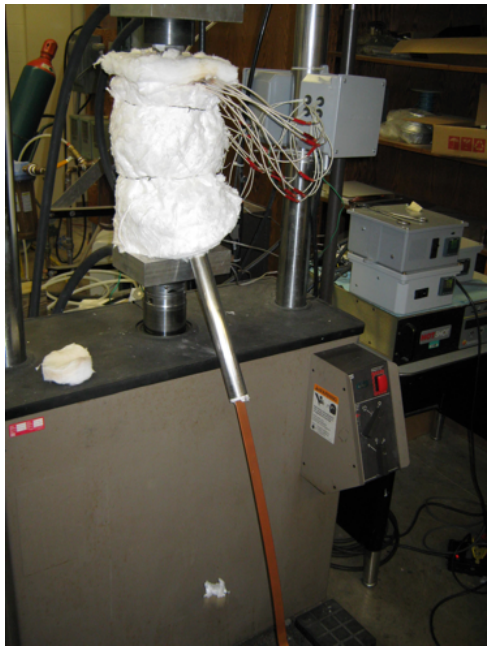
10 ft. by 4 ft. (3.7 m^2) aluminum minichannel solar collector

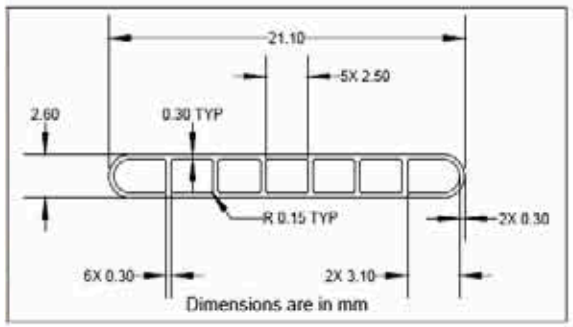
- Aluminum minichannel tubes = $440
- Headers = $28
- Collector frame and glass purchased = $500
- TIG welding = $1056
- Total = $2024, or **$50.6/ft^2 (or $544.65/$m^2$)**
- Estimated cost for mass produced unit: **$14.43/$ft^2$ (or $155.32/$m^2$)**

Average conventional collector **$51.42/$ft^2$ (or $553.50/$m^2$) ***

* GTM Research and SEIA, 2011

Copper Extrusion





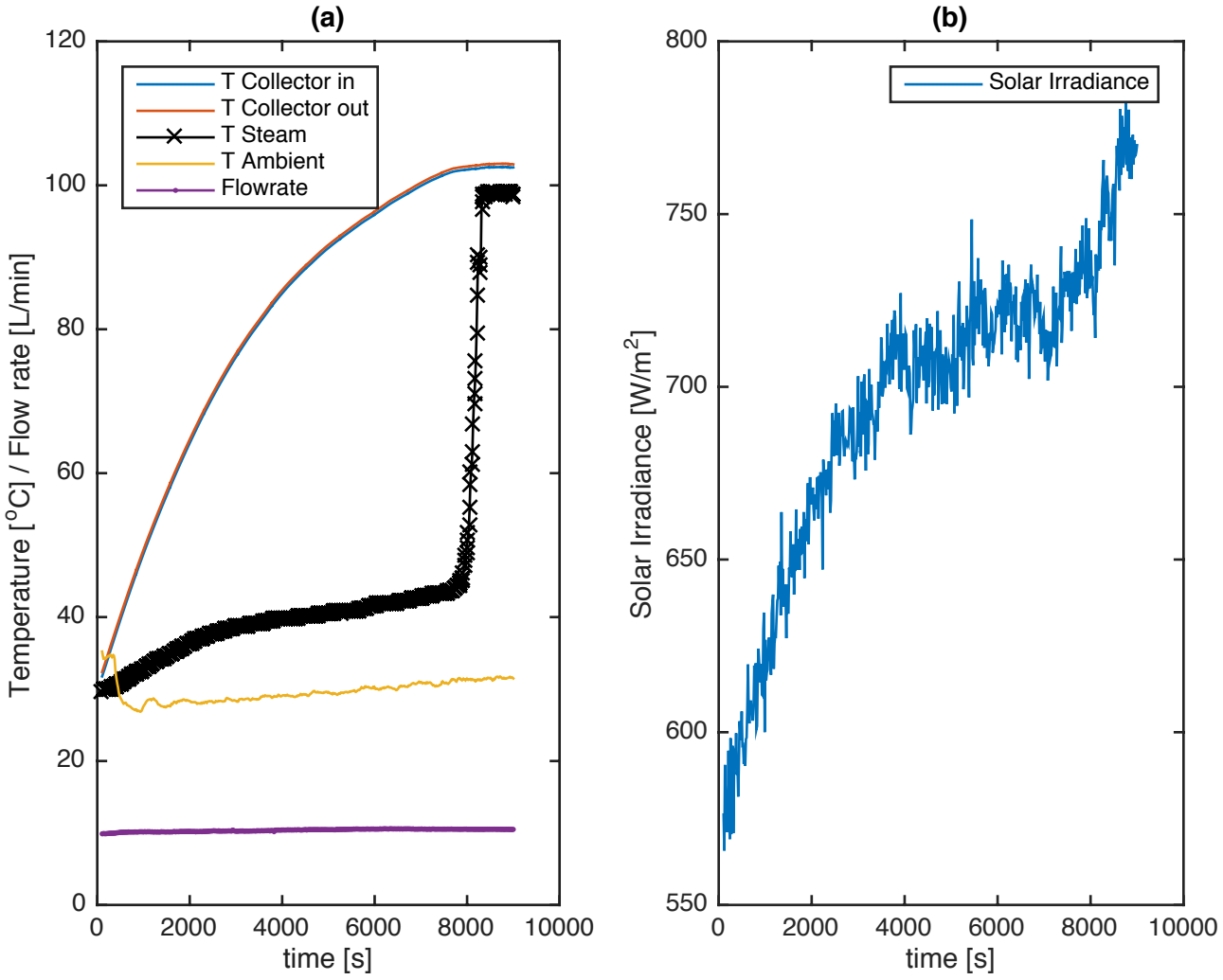
Copper minichannel tubes manufactured by Prof. Kraft, at Ohio University

Test Stand

Variable Angle of Inclination

Steam Generator

Low-Grade Steam Generation



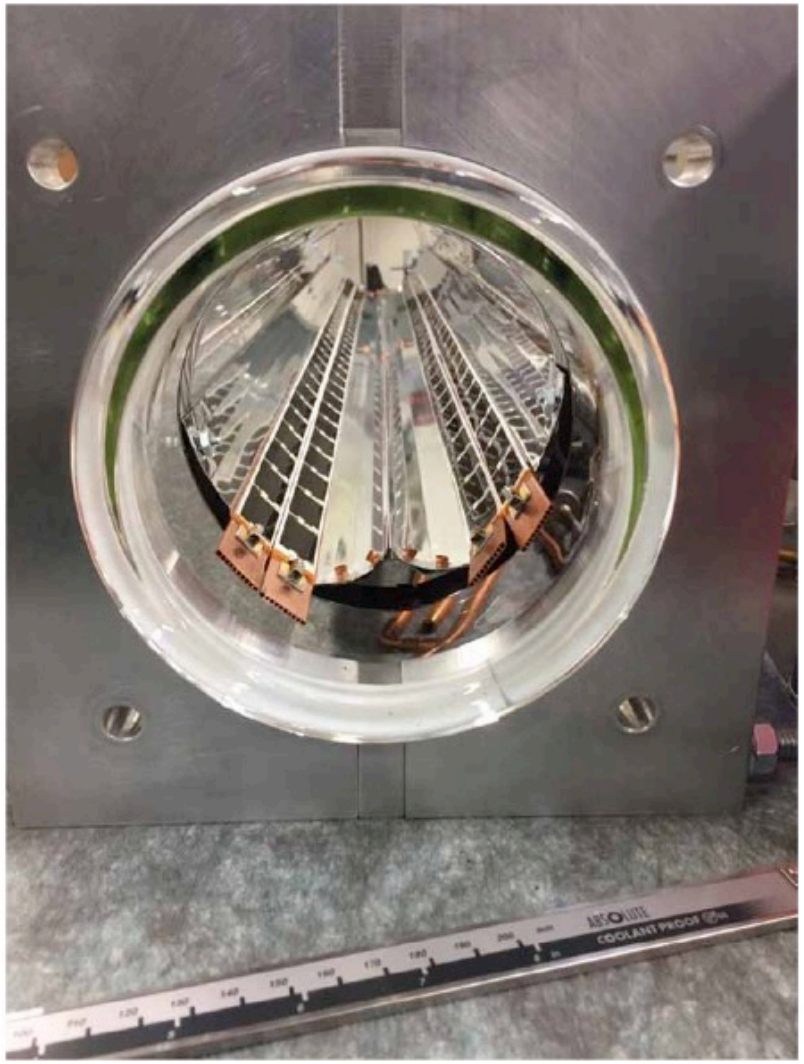
Industrial Heat Applications (Prof. Winston's group)

Installation in Mongolia

Non-imaging optics-based External Compound Parabolic Concentrator (XCPC)

Sugar Refinery in Dubai

High Temperature + Electric Power



650 Celsius (1202 °F)

Factors Influencing Policy

San Bruno Explosion (2010)

Aliso Canyon Gas Leak (2015)

California's Aliso Canyon blowout led to largest U.S. methane leak ever

Changes in Incentives

CPUC approved Advice No. 4953 (April 29, 2016)

SoCalGas:

Step 1 incentive level of $70/therm for Single Family

$25/therm for Commercial/Multifamily applications.

Natural Gas-Displacing Single-Family System Incentive Steps

Step	Incentive per annual therm displaced ()For SoCalGas only	Maximum Incentive Single-Family Residential Projects ()For SoCalGas only	Budget Allocation (in millions)
1	$29.85 ($70.00)	$4,366 ($10,238)	$7,907,636
2	$25.37	$3,710	$4,900,000
3	$14.30 ($0)	$2,091	$784,000
4	$3.23 ($0)	$472	$1,323,000

California Solar Initiative Thermal Program Handbook Rev 18.2.0

What does this mean?

- Water heating is the most significant residential end use for natural gas in California.
- Natural gas is used to heat water in nearly 90 percent of homes
- Represents 49% of the average 354 therms of annual household consumption.
- 173 therms/year x $70 / therm = $12,110 (Max. Incentive of $10,238)
- Average cost of SWH system in residential sector in California is $8,364

The system is paid in one year!

Acknowledgements

We would like to thank the California Energy Commission for providing the funding for some of these projects (Contract # POEF01-M04). We also thank ARPA-E for funding provided to UC Solar, and UC Solar for covering part of this trip.

and students:

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