
2008 Solar Annual Review Meeting

Session: Parabolic Troughs
Organization: NREL



Chuck Kutscher
NREL
chuck_kutscher@nrel.gov

NREL/PR-550-43332
Presented at the Solar Energy Technologies Program (SETP) Annual Program Review Meeting held
April 22-24, 2008 in Austin, Texas



Project Description



- R&D activities at NREL and Sandia aimed at lowering the delivered energy cost of parabolic trough collector systems
- FOA awards to support industry in trough development

Major FY08 Activities



- Trough Solar Field
- Power Cycle and Balance of Plant
- Trough Systems Integration
- FOA Support

FOA Trough Contracts



- Abengoa – advanced trough (\$499K)
- Abengoa – polymer reflector (with Conductive Science, Inc.) (\$448K)
- Alcoa – advanced all-aluminum trough (\$399K)
- Solar Millennium – advanced high-temperature trough (\$350K)



Relationship to Solar Program Goals

“...to make CSP cost competitive in the intermediate power markets by 2015 (~7¢/kWh with 6 hours of storage) and in baseload power markets (~5¢/kWh with 16 hours of storage) by 2020.”

Project overview

Primary Objectives



- Support development of near-term parabolic trough technology for central station power generation
- Support development of next-generation trough fields
- Support expansion of U.S. trough industry

Major FY08 Activities



- Improving reflector optics
- Reducing receiver heat loss (including improved receiver coating and mitigating hydrogen accumulation)
- Measuring collector optical efficiency
- Optimizing plant performance and reducing cost
- Reducing plant water consumption
- Directly supporting industry needs, including FOA support

Milestones



<u>Milestone</u>	<u>Date</u>	<u>Status</u>
Lab tests of advanced receiver	Jan. 2008	Completed Jan. 2008
Train FPL staff on IR HCE survey	March 2008	Completed March 2008
Complete instrumentation and qualification tests of optical test loop	March 2008	Completed April 2008
TOP alignment tests at Saguaro	March 2008	Completed Nov. 2007
Organize trough sessions at SolarPACES	March 2008	Completed March 2008
Prepare report on CSP plant water usage	June 2008	Draft April 2008

Milestones (cont.)



<u>Milestone</u>	<u>Date</u>	<u>Status</u>
Data for receiver heat loss with inert gas mixtures	June 2008	On schedule
Report on H ₂ mitigation and future plans	August 2008	On schedule
Report/paper on distant observer feasibility	September 2008	On schedule
Report summarizing industry support activities	September 2008	On schedule
Report summarizing FOA support	September 2008	On schedule

Budget



Agreement	FTEs	\$(K)	Subcontract \$(K)
Solar Field	5.3	1,739	0
Power Cycle and Balance of Plant	0.3	174	75
Systems Integration	2.45	671	30
FOA Support	1.0	315	0
FOAs	--	--	1,695

Personnel



NREL: Chuck Kutscher, Tim Wendelin, Cheryl Kennedy,
Greg Glatzmaier, Gary Jorgensen, Frank Burkholder,
Judy Netter, Allison Gray

Sandia: Greg Kolb, Rich Diver, Tim Moss, Nate Siegel,
Bob Bradshaw

Relevance to Program Plans & Goals



Trough goals:

- Reduce collector cost from \$260/m² to \$160/m²
- Increase field efficiency from 42% to 52%
- Increase operating temperature from 390°C to 450°C
- Reduce coating emittance to 0.07

Relevance of Activities:

- Supporting manufacturers in development of lower cost troughs
- Optical measurement support and improved coatings will increase collector efficiency
- New heat transfer fluids will allow higher operating temperature

Technical Highlights



- VSHOT optical measurements in support of Acciona, Abengoa and SkyFuel; transferred to Solar Systems
- TOP measurements at Saguaro and SEGS II-VII
- IR receiver measurements at SEGS; transferred to industry
- Indoor tests on Solel and Schott receivers
- Construction of outdoor optical test loop
- Progress on low emittance absorber coating
- Organized 9 trough sessions at SolarPACES
- Completed draft report on water usage

Issues and Solutions

- Delivery of new SkyFuel trough to NREL delayed; have obtained Gossamer frame to test
- Sagging of receiver tubes noted in TOP alignment tests at Saguaro; additional tests planned for fall 2008
- Greatly increased number of requests for support from existing and emerging industry and FOA contractors

FY08 Progress Report

What has been accomplished thus far?



Costing

<i>Company or Organization</i>			
Project Beginning Date	FY07 Carryover	FY08 Budget	Total Budget
10/1/2003	\$4.05 million	\$2.57 million	\$6.62 million

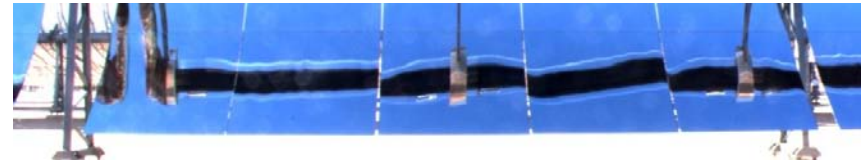
VSHOT Testing

- Applied in field to test Abengoa collectors in Spain
- Used to help SkyFuel refine their new reflector design
- Enhanced capability and transferred to Solar Systems

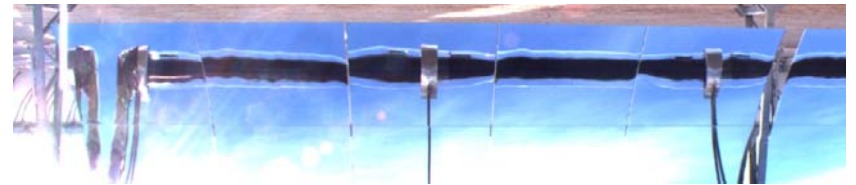


TOP Alignment

- Tested at Saguaro and SEGS II-VII
- Testing takes 4 min/module (70 min/module when re-alignment required)

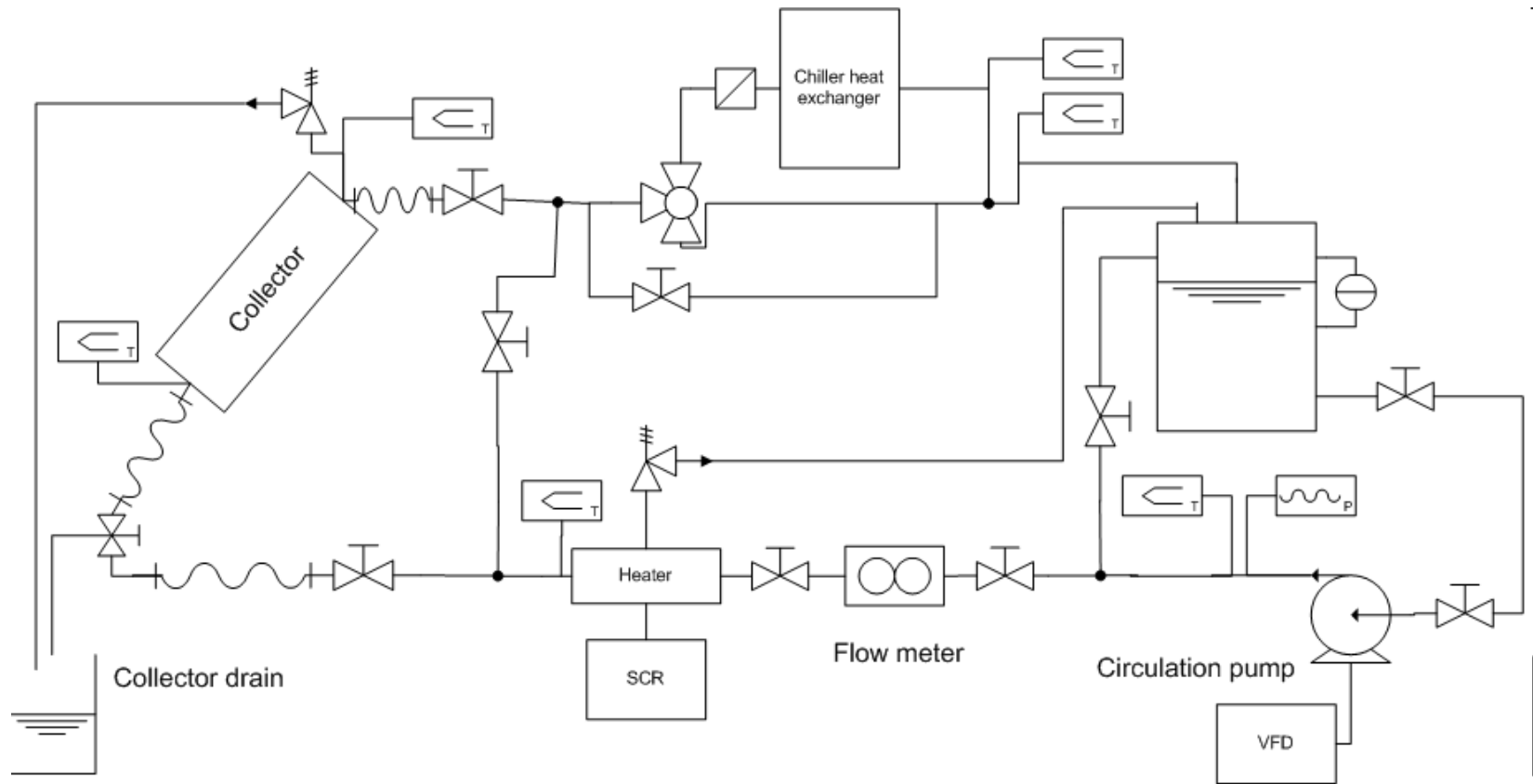


Before

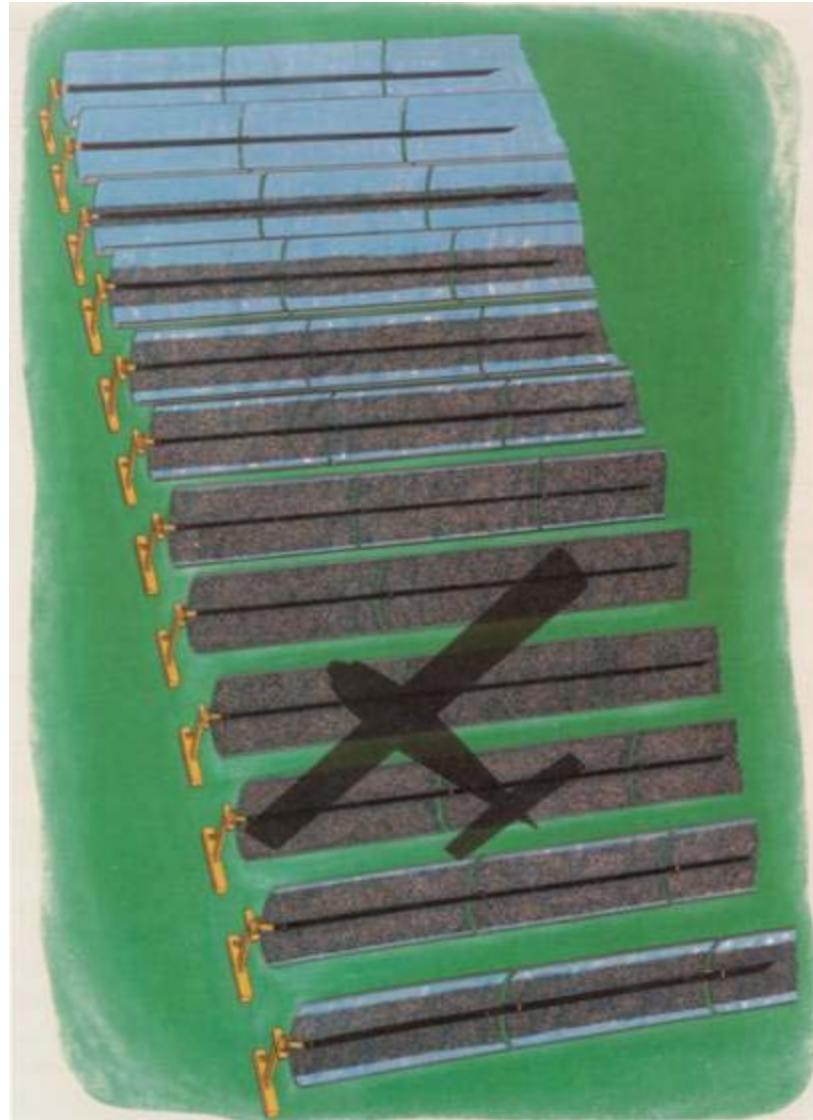


After

Total Collector Optical Efficiency

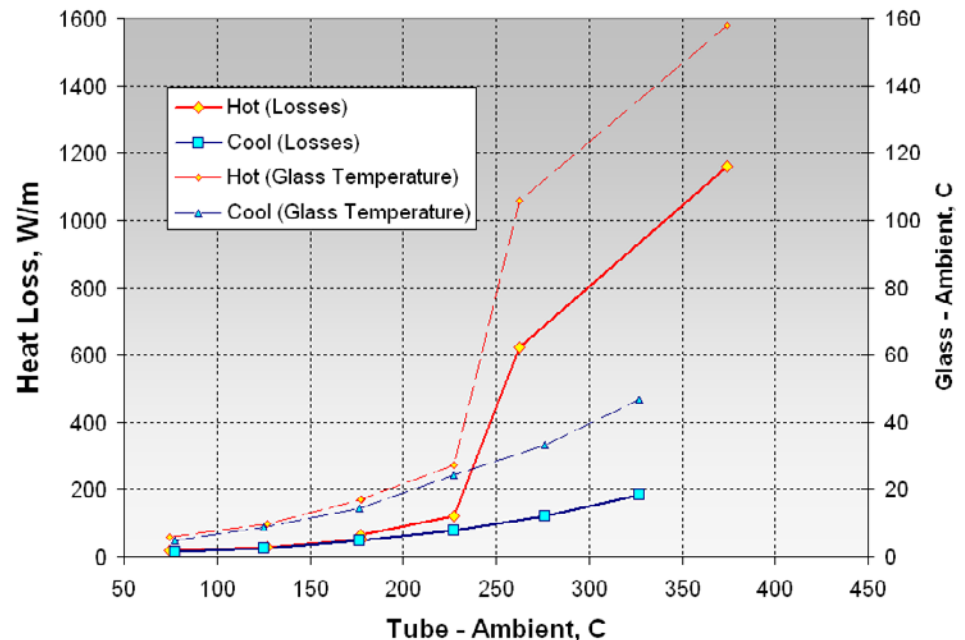


Distant Observer



Receiver Heat Loss Measurements

- Tested new Schott and Solel receivers
- Tested tubes from field with and without hydrogen contamination



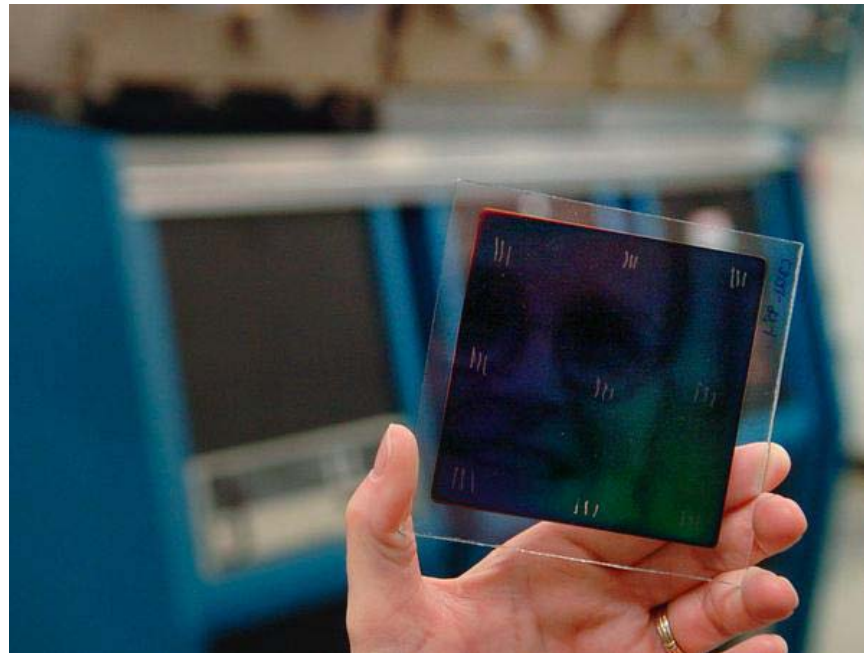
Field IR Receiver Measurements

- IR camera/GPS unit can measure glass temperature of 6,000 receivers in one day



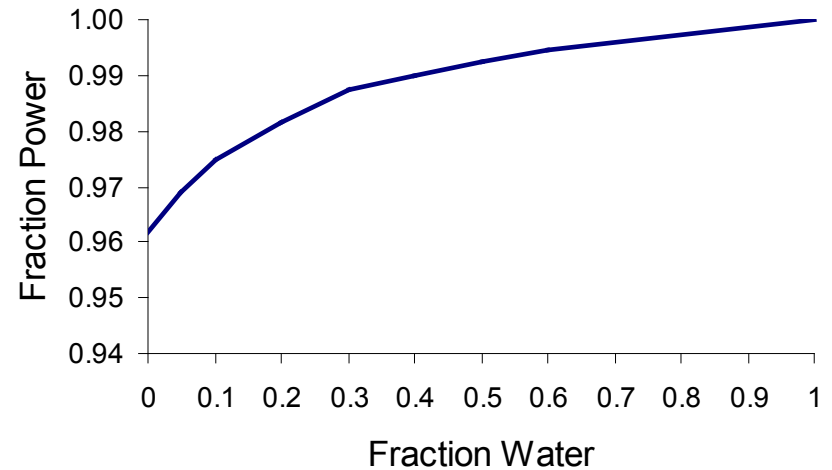
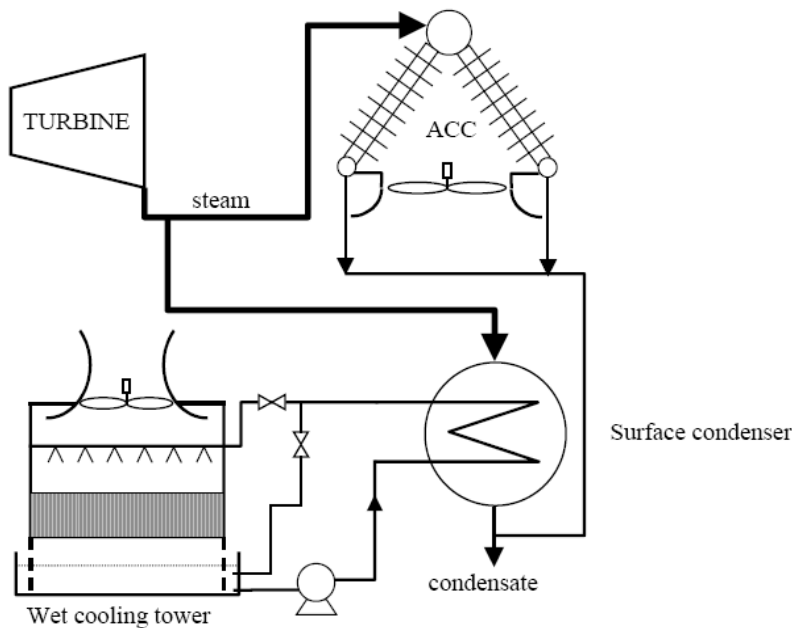
Optical Materials R&D

- Deposited proof-of-concept improved solar selective coating with lower emissivity (0.07 vs. 0.10); absorptivity > 95%, stable at temperatures > 500C
- Filed for patent (11/07)
- Negotiating with 2 potential licensees (1/08)



Report on Reducing CSP Water Usage

- Hybrid air/water cooling systems can reduce water use 80% with modest performance and cost penalties



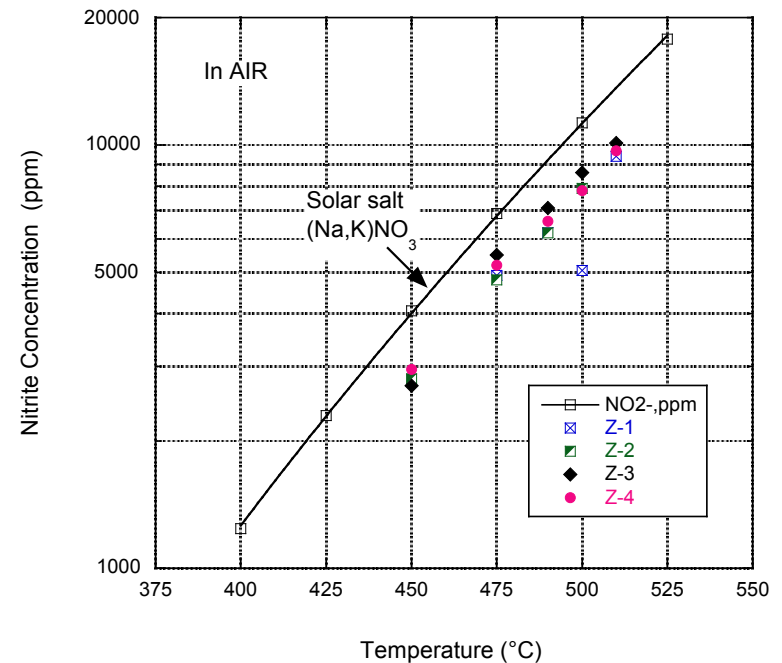
Improved Molten Salt Mixtures

- Blending four simple nitrate salts gives low freezing and high operating temperatures, good fluid properties

Mixture Composition vs. Solidification Testing
Liquid Mixtures Observed at $T < 100^\circ\text{C}$



Chemical Stability Tracks Solar Salt to 500°C

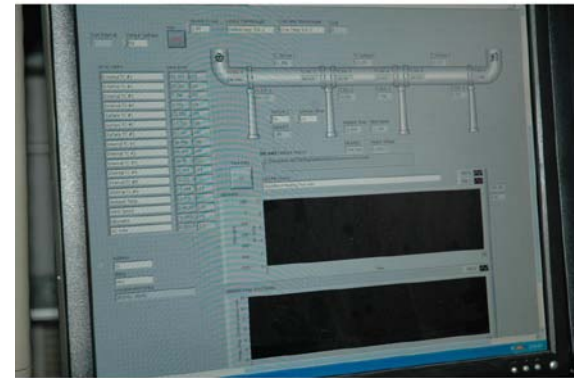


HCE Impedance Heating Test

- Flow electrical current through HCEs to preheat prior to flowing salt
- Can be used to recover from a salt freeze-up accident



HCE Test Rig



Impedance
Heating
Controls

FY09 Planned Activities



- a) Follow-on efforts
 - current R&D activities continuing
 - additional transfer of VSHOT to industry
 - updated cost models for troughs/thermal storage
- b) New directions
 - field measurements at Ausra CLFR installation
- c) Budget Table (FTEs, \$FTE, Subcontract Info)
- d) Projected Milestones
 - new milestones for ongoing activities TBD
 - testing of distant observer system
 - O&M cost analysis report
 - report on CLFR cost and performance

FY10 and Beyond Ideas



a) Future Projects

- demonstrate use of molten salt in the collector field
- extend trough test & evaluation capabilities to other technologies (CLFR, CPV and towers)
- develop strategies to integrate trough-storage system
- explore high-voltage DC transmission lines to move CSP electricity eastward
- develop larger aperture trough

b) Outside the Box Ideas

- explore adiabatic compressed air energy storage
- CSP/CPV hybrids

c) Vision of the solar future

- a mix of technologies with enhanced storage and transmission

Long Distance Transmission

