
2008 Solar Annual Review Meeting

Advanced High Temperature Trough Collector Development

Session: Thermal Storage

Company or Organization: Solar Millennium LLC/Flagsol

Funding Opportunity: CSP Advanced Systems Solicitation



Ray Dracker

Senior Vice President – Solar Millennium LLC

dracker@solarmillennium.com (510) 524 4517

Klaus-Jürgen Riffelmann: Director R&D - Flagsol



Advanced High Temperature Trough Collector Development

Relationship to DOE Solar Program Goals

a) Solar Multi-year Program Plan:

- *Development and expansion of next-generation parabolic trough technology for centralized power generation.*

b) CSP Subprogram Goals:

- *Achieve a design point solar-to-electric efficiency of 25.6% and an annual solar-to-electric efficiency of 15.5%*
- *Make CSP cost competitive in the intermediate power markets by 2015 (~7¢/kWh with 6 hours of storage) and in base load power markets (~5¢/kWh with 16 hours of storage) by 2020*

c) Joule Targets: **GOAL 1.1 ENERGY DIVERSITY:**

- *Increase our energy options and reduce dependence on oil, thereby reducing vulnerability to disruptions and increasing the flexibility of the market to meet U.S. needs.*

Advanced High Temperature Trough Collector Development



Project overview: Objectives

Establish the potential benefits of salt heat transfer fluid

- High operating temperature
- Low freezing temperature
- Single heat transfer and energy storage fluid



Design and demonstrate an advanced geometry parabolic trough collector, capable of operation with oil, molten salt or steam heat transfer fluid

the “NT Pro” Platform

Reduce Parabolic Trough Solar Field Costs and Improve Performance

Demonstrate low freezing temperature salt HTF at a pre-commercial scale

Advanced High Temperature Trough Collector Development



AndaSol 1 SkaLET Collector (10% improvement over LS3)

NT Pro Collector
22% Improvement Goal
compared to current
technology

- *reduction of the specific collector investment costs (costs per aperture area)*
- *reduction of assembly costs by advanced assembly concepts*
- *Improve the optical performance of the collector*
- *Further gains on overall plant economics with salt HTF*

Molten Salt Heat Transfer Fluid

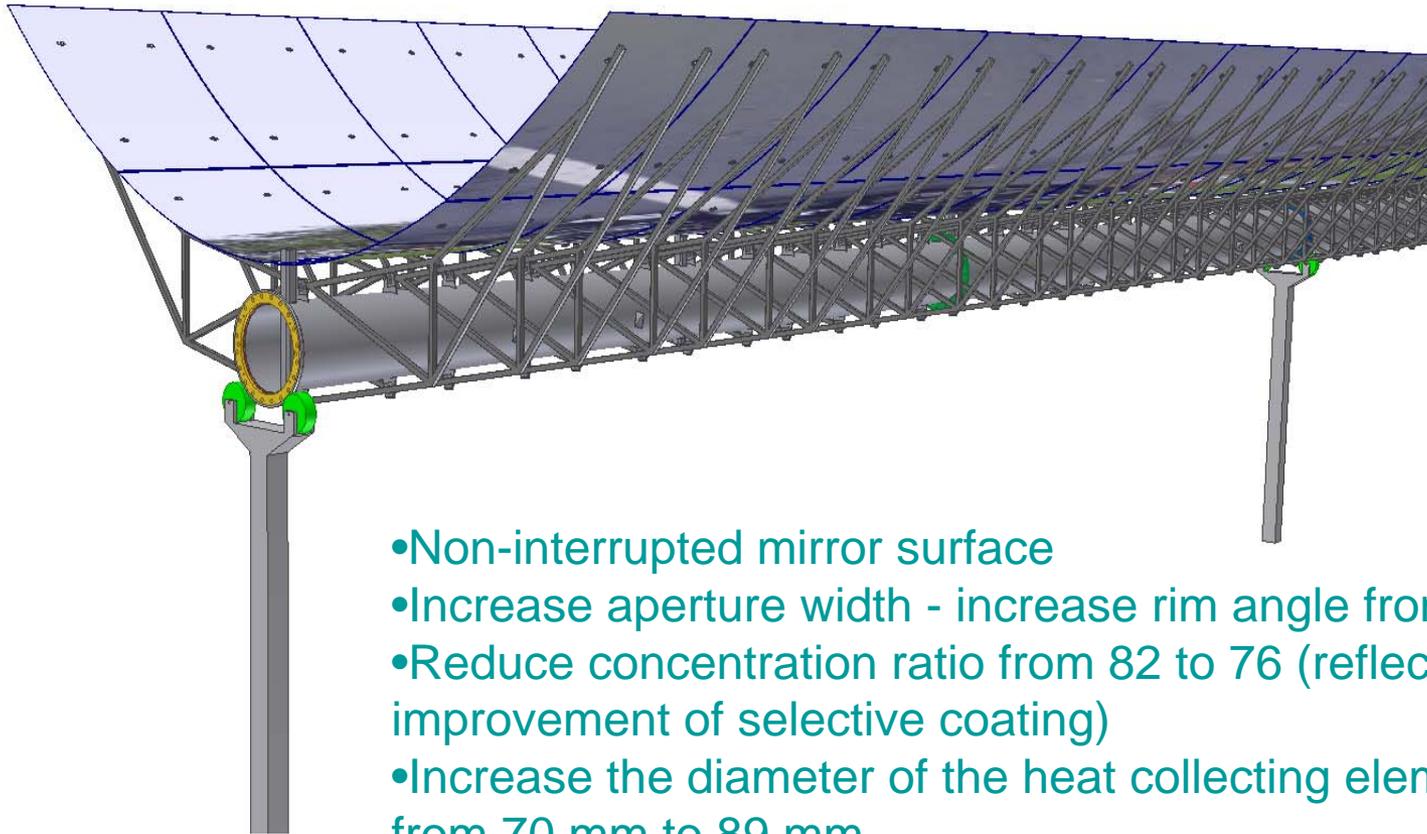


AndaSol-1 &- 2 plants in Spain: 1,020 MWh, 7.5 full load hrs, 31,000 tons of molten salt

- Solar Millennium has been investigating advanced HTF fluids for several years.
- Patent application for a multinary salt based on nitrates/nitrides
 - low degradation up to 500 °C (932 °F)
 - freezing point below 100 °C (212 °F).
 - low cost
 - easy to handle, non-toxic and non-flammable.



NTPro Collector



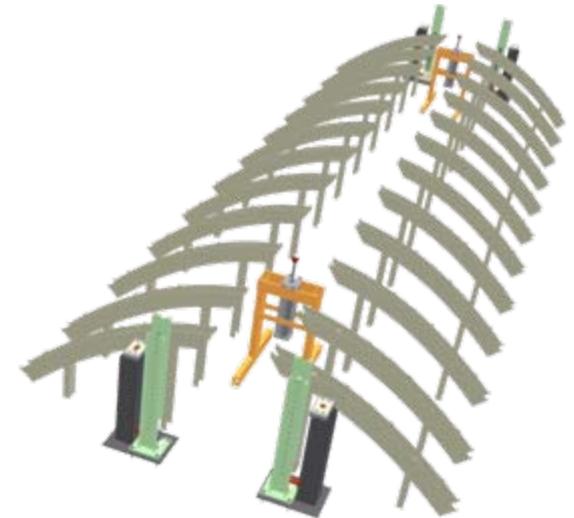
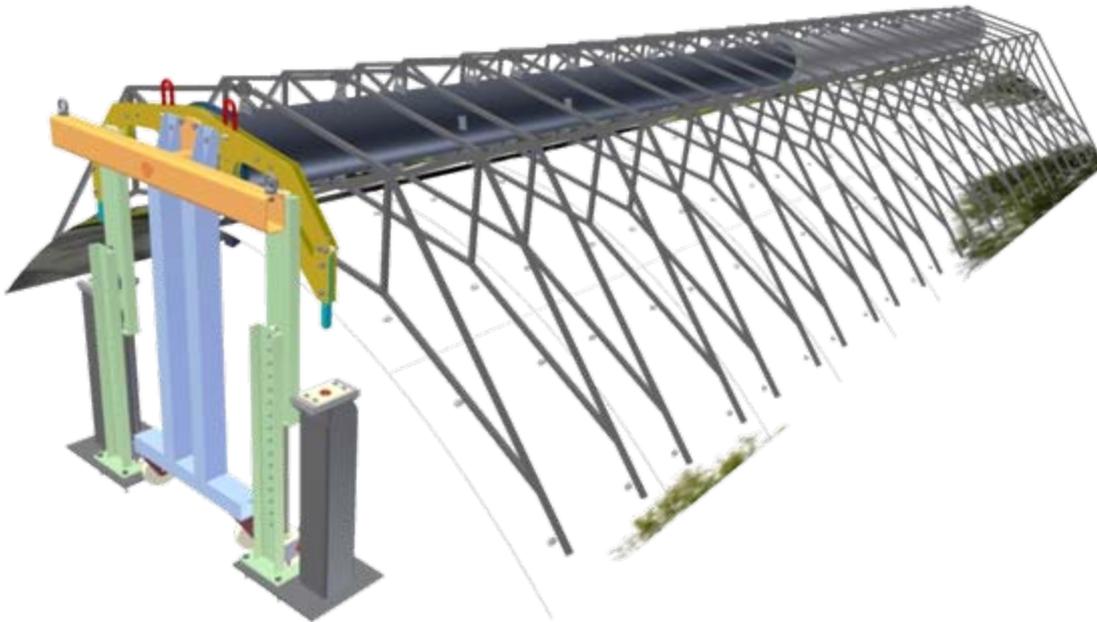
- Non-interrupted mirror surface
- Increase aperture width - increase rim angle from 80° to 89°
- Reduce concentration ratio from 82 to 76 (reflects improvement of selective coating)
- Increase the diameter of the heat collecting element (HCE) from 70 mm to 89 mm.
- Reduce pressure drop through collector

Advanced High Temperature Trough Collector Development

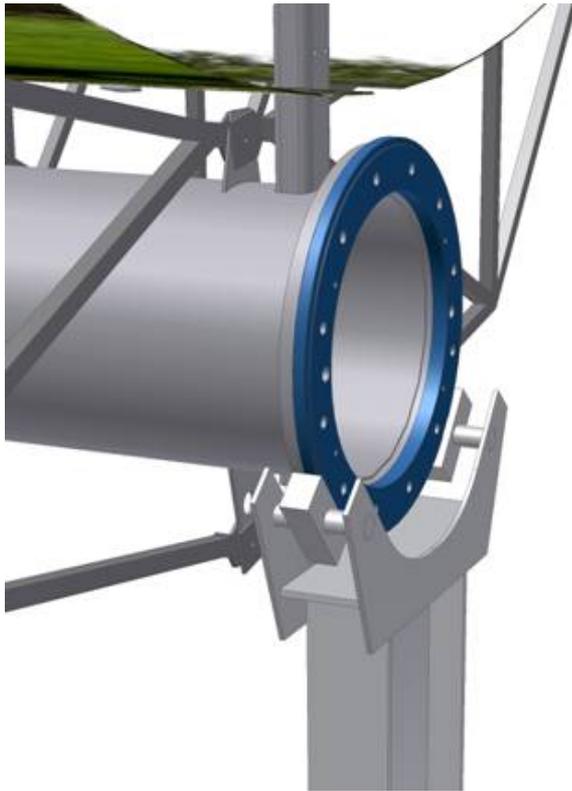


New assembly concept

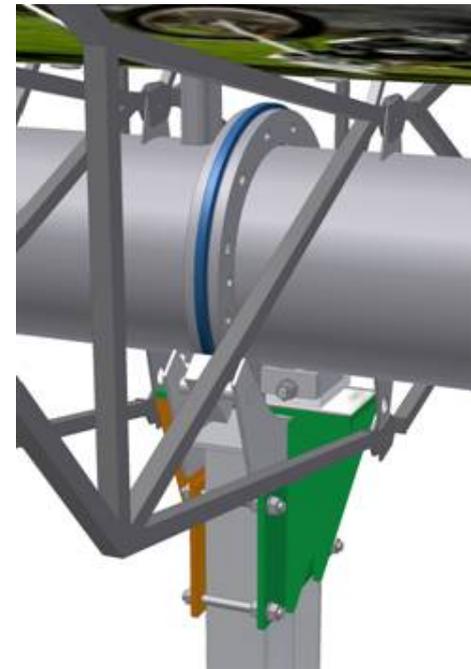
- Reduced field labor requirements
- Increase length of a solar collecting element (SCE) from 12 m to 19 m;
- Increase length of the HCE to 4.722 m (4 HCE's per SCE)



Assembly of two Solar Collector Elements using bearing flanges



Increase the total length of one solar collector assembly from 148 m to 192 m.



Advanced High Temperature Trough Collector Development



Major FY08 Activities

- Investigate the benefits and issues associated with use of molten salt as the HTF in parabolic trough power plants
 - *Conceptual design of molten salt systems*
 - *Operation strategy for molten salt systems*
 - *Investigate the thermodynamics of the high temperature cycle*
 - *Identification of new components*
 - *Cost, performance and economic analysis (salt vs. oil plants)*
 - *Risk analysis*

Advanced High Temperature Trough Collector Development



Major FY08 Activities

- Complete design and construction of the NTPro VP1 Demonstration Loop at Kramer Junction



SkalET Demo Loop – Kramer Junction 2003

Specify and procure components

*In collaboration with FPLE,
construct the demonstration loop
within the SEGS V solar field, with
complete thermal integration.*

Advanced High Temperature Trough Collector

Development: Schedule/Milestones - 2008

ID	Task Name	2008													
		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
1	Complete salt-HTF system definition and performance estimate	■				◆	5/1								
2	Complete economic evaluation of salt-HTF power systems			■		◆	6/1								
3	Evaluate relative benefits of salt-HTF power systems compared to conventional alternative				■		◆	7/1							
4	Complete specification of NTPro collector components	■					◆	6/1							
5	Procure demo-loop major component hardware	■						◆	7/1						
6	Construct jigs and begin collector assembly							■		◆	9/1				
7	Complete collector assembly								■			◆	12/31		

Advanced High Temperature Trough Collector Development



Project Budget - 2008

	Total Cost	Solar Millennium Cost Share
Phase 1 Salt Systems Analysis	\$437,500	\$87,500
Phase 2 Design, Procurement and Construction – Kramer Demo Loop	\$2,000,000	1,258,000
Total Project Costs (Through 2011)	\$5,920,000	\$2,608,000

Advanced High Temperature Trough Collector Development



Key Project Personnel - 2008

Ray Dracker	Project Director
Klaus-Jürgen Riffelmann	Project Engineer
Andras Nady	Sr. Process Engineer
Nils Gathmann	Sr. Engineer – Salt Technology
Jake McKee	Construction Engineer
Jens Kötter	Engineering and Procurement
Shujia Ma	Financial Analyst
Paul Nava	Engineering and Construction Supervision
Bruce Kelly (Nexant)	Salt Systems and Components
Babul Patel (Nexant)	Systems Engineering

FY08 Progress Report



Accomplishments to-date

- a) NT Pro Collector Design Completed
- b) Advanced Nitrate Salt HTF Patent Pending
- c) Long Lead Time Components for Kramer Junction Demonstration Loop Specified and Ordered
- d) Advanced geometry HCE for both VP1 and Salt has been defined in conjunction with Schott

Advanced High Temperature Trough Collector Development



Anticipated accomplished in the 3rd and 4th Quarters

- Completion of the Advanced Salt HTF Solar Field Cost and Performance Assessment
- Complete NTPro VP1 collector procurement and assembly in collaboration with FPLE at Kramer Junction Power Plant



Future Activities

1. FY09 Planned Activities

- a) Complete checkout and commissioning of the VP1 NTPro Demonstration Loop at Kramer Junction
- b) Conduct detailed performance tests on the VP1 NTPro Demonstration Loop
- c) Prepare detailed designs for the modifications required to operate the demo loop with salt HTF
- d) Specify and order long lead time salt components (Heat collection elements, heat exchangers)

Milestone: *Verify optical and thermodynamic performance projections of the advanced geometry collector*

Future Activities



FY '10

- Commissioning of the Salt HTF loop
- Test of operating strategy, filling, evacuation
- Optimization of heat tracing system

and Beyond

- DSG and Salt HTF Subfields at AndaSol 3